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OFFICE OF
PREVENTION, PESTICIDES AND
TOXIC SUBSTANCES

April 16, 2002

MEMORANDUM

SUBJECT: **ATRAZINE**. HED's Revised Human Health Risk Assessment for the Reregistration Eligibility Decision (RED). DP Barcodes: D272009, D281936, D281917. PC Code: 080803. Case No. 0062.

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This memorandum, the accompanying human health risk assessment and attachments serve as the HED Revised Preliminary Human Health Risk Assessment for the RED for atrazine. The attachments include: (1) HED Toxicology Chapter dated 04/11/02, L Taylor (Attachment I); (2) Fourth Report of the Hazard Identification Assessment Review Committee (HIARC) memoranda dated 4/5/02, L. Taylor (Attachment II); (3) Reassessment Report of the FQPA Safety Factor Recommendations (4/8/02), B. Tarplee (Attachment III); (4) HED Product and Residue Chemistry Chapter dated 4/16/02, C. Eiden and D. Soderberg (Attachment IV); (5) Anticipated Residues and Acute and Chronic Dietary Exposure Assessments for Atrazine dated 01/18/01, C. Eiden and D. Soderberg (Attachment V); (6) HED Occupational and Residential Exposure Assessment and Recommendations for the Reregistration Eligibility Decision Document for Atrazine dated 04/16/02, G. Bangs (Attachment VI); (7) EFED Drinking Water Exposure Assessment, J. Lin, H. Nelson, and M. Frankenberry (Attachment VII); and (8) Review of Atrazine Incident Reports, J. Blondell (Attachment VIII). These attachments contain the basic information used here to describe the overall exposure and risk estimates associated with the use of atrazine. Cumulative risk assessment, which considers risks from other pesticides which have a common mechanism of toxicity is not addressed in this document.

This document contains revisions to the revised preliminary human health risk assessment dated January 19, 2001 made in response to the Phase II Review 60-day public comment period.

HED notes that the following raw agricultural commodities were excluded from the preliminary dietary risk assessments for atrazine because there is no reasonable expectation of residues in these commodities: secondary residues in poultry meat, fat, and meat byproducts and eggs, and meat, fat, and meat byproducts of hogs.

To date, HED has conducted drinking water exposure assessments for pesticides using screening-level water quality models for the most part. However, because atrazine is regulated under the Safe Drinking Water Act (SDWA), and the registrant has voluntarily conducted additional monitoring, there are more data available to assess exposures to atrazine in finished drinking than for any other pesticide. For this reason, monitoring data on residues of atrazine in finished drinking water have been used for this assessment in lieu of the models usually employed. Because of the volume of information available through various data sets for thousands of community water systems and hundreds of rural wells, HED developed a methodology by which these data have been used initially in a screening-level assessment of exposure. Community water systems identified as of potential concern under the screening-level approach have been further assessed using a probabilistic approach. The probabilistic methodology uses all distributions of data available on drinking water consumption, body weight, and concentrations of atrazine and the chlorotriazine metabolites in finished drinking water. The results of this probabilistic exposure assessment have been included in this document.

REVISED HUMAN HEALTH RISK ASSESSMENT

Atrazine

April 16, 2002
Reregistration Branch 3
Health Effects Division
Office of Pesticide Programs
U.S. Environmental Protection Agency

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1.0 EXECUTIVE SUMMARY

Background

This document contains the Health Effects Division's (HED's) revised human health risk assessment for atrazine. HED is providing this document in support of the reregistration eligibility decision for atrazine, and to conclude the special review on atrazine.

Atrazine, a systemic herbicide that blocks photosynthesis, is currently one of the two most widely used agricultural pesticides in the U.S. Approximately 64 to 75 million pounds (lbs) of active ingredient (ai) are applied per year. About three-fourths of all field corn and sorghum are treated with atrazine annually for weed control. Seventy percent (70%) of the atrazine applied to corn and sorghum is used prior to emergence (preemergence), and thirty percent (30%) is applied postemergence.

Atrazine is metabolized to four hydroxyatrazine compounds and to three chlorinated atrazine compounds, and conjugates of these compounds. The hydroxy compounds are the predominate metabolites found in plants, while the three chlorinated compounds (desethylated atrazine, desisopropyl atrazine, and diaminochlorotriazine (DACT)) predominate in animal tissues, and in soils and water.

Atrazine is the most commonly detected pesticide in ground and surface water. It has been the subject of multiple monitoring programs conducted by the registrant, academia, states, and government agencies, in particular the U.S. Geological Survey (USGS). Atrazine's frequent detection in streams, rivers, groundwater, and reservoirs is related directly to both its volume of usage, and its tendency to persist in soils and move with water.

Regulatory History

Atrazine's unique regulatory history began in the early 1990s. Atrazine's occurrence in the environment prompted the Environmental Protection Agency's (EPA or the Agency) Office of Water (OW) to regulate atrazine under the Safe Drinking Water Act (SDWA), and in 1991 OW established a Maximum Contaminant Level (MCL) of 3 parts per billion (ppb) for atrazine. Under the SDWA, atrazine has been subject to compliance monitoring. OW has also established a one-day Health Advisory Level (HAL) for atrazine of 100 ppb. Prior to EPA initiating a Special Review, the registrant voluntarily instituted several risk reduction measures to address concerns raised about surface water and groundwater contamination by atrazine. In 1990, the following measures were undertaken by the registrant to address groundwater exposure concerns:

- Reduction of the application rate for corn and sorghum to 3.0 lbs ai/acre from 4.0 lbs ai/acre.
- Classification of all atrazine-containing products (except for the lawn care, turf, and conifer uses) as Restricted Use Pesticides (RUPs).
- Institution of a wellhead protection plan requiring 50 foot setbacks around all wells for mixing, loading, or applying atrazine-containing products.
- Deletion of most noncrop land uses that typically had high application rates, such as industrial sites, medians, railroad rights-of-way, and noncrop areas of farms.
- Prohibition of chemigation (applying atrazine through irrigation systems).

In 1992, the following additional measures were undertaken to address concerns about atrazine contamination of surface water sources:

- Further reduction of the total seasonal application rates for corn and sorghum to 2.5 lbs ai/acre per year. This rate includes: a split application at 1.5 lbs ai/acre per year preemergence use and a 1.0 lbs ai/acre per year postemergence use, a split application at 0.5 lbs ai/acre per year preemergence use and a 2.0 lbs ai/acre per year postemergence use, and a preemergence use at 2.0 lbs ai/acre. The total annual application rate, any combination of pre- and postemergent use, is not to exceed 2.5 lbs ai/acre.

- Expansion of the setback requirements, including: a 50 foot setback around surface water sources when workers are mixing and loading atrazine-containing products; a 66 foot application (ground and aerial) setback from points of entry where field surface water runoff enters surface water sources; and, a 200 foot application setback around lakes and reservoirs.

- Institution of construction requirements for bulk storage facilities to eliminate point source contamination from spills.

In November 1994, EPA initiated a Special Review for the Triazine Pesticides, atrazine, simazine and cyanazine, based on cancer risk concerns for people potentially exposed to atrazine through consumption of food and drinking water, and lawn treatments. The basis for the Special Review also included cancer risk concerns for workers exposed to atrazine in various agricultural settings and application scenarios. At the time that the Special Review was initiated, atrazine and the other triazines were classified as Group C carcinogens (possible human carcinogens) based on an increase in tumors in laboratory animals. The potential cancer potency was quantified for atrazine and the other triazines using a linearized, low-dose extrapolation model (Q_1^*).

Atrazine is still subject to the conditions of the Special Review and is undergoing reregistration and tolerance reassessment under the Food Quality Protection Act (FQPA). In addition, atrazine and the other Triazines are included in priority Group 1 for the purpose of tolerance reassessment. Since the Special Review was initiated, EPA has received and reviewed a large volume of new data on atrazine. These include new toxicology data on the mode of action leading to early onset of mammary tumors in the Sprague-Dawley strain of rat, and substantial amounts of drinking water monitoring data. Based on the refinements to and completeness of the atrazine database, the Agency believes it is now appropriate to prepare a revised human health risk assessment.

Currently Registered Uses of Atrazine

Atrazine is an herbicide registered for the control of broadleaf weeds and some grassy weeds. Atrazine is currently used on corn (field and sweet), sorghum, sugarcane, wheat (where application is to wheat stubble on fallow land following wheat harvests; wheat is not the target crop), guava, macadamia nuts, orchard grass and hay, range grasses, and southern turf grasses. Atrazine is most widely used on corn followed by use on sorghum and sugarcane. The uses on orchard grass and hay are not supported by the primary producer, and HED is recommending the revocation of the orchard grass and hay tolerances.

Atrazine is registered for use on range grasses for the establishment of permanent grass cover on rangelands and pastures under the Conservation Reserve Program (CRP) in four states: OK, NE, TX, and OR. The CRP is administered by the U.S. Department of Agriculture (USDA). There are prohibitions against grazing on these CRP lands, and cutting the grasses for hay, except in national emergencies, such as severe drought. There are also "right-of-way" uses with grazing restrictions. Atrazine is also registered for use on the following nonagricultural use sites: lawns, golf courses, and sod farms. Atrazine is formulated variously as dry flowables, and water-based flowable formulations.

Potential Sources of Exposure to Atrazine

HED has considered potential exposure pathways based on atrazine's use pattern as described above. Atrazine’s physical/chemical properties affect the fate and transport of the compound and its availability in the environment, in edible portions of plants, in water used for drinking, and on treated foliage. It is generally accepted that atrazine's relative persistence and mobility in the environment coupled with its widespread use on animal feed crops (corn) result in the frequent occurrence of chlorotriazines in surface and groundwaters located in high use areas. The predominate exposure pathway for atrazine and its chlorinated metabolites is the oral route via drinking water. Because atrazine’s hydroxylated metabolites predominate in plants, this provides an opportunity for oral exposures to atrazine's hydroxylated metabolites through the transfer of residues in animal feeds to humans through the diet. Dermal exposures to atrazine, *per se,* through the transfer of residues from foliage during and after applications of atrazine products are expected because atrazine is resistant to photolysis and hydrolysis, and residues on plant surfaces are likely to be the parent compound, only. Although not expected to be a dominant exposure pathway because of low volatility, there is some possibility of inhalation exposures to atrazine during application.

Significant Sources of Exposure to Atrazine

As a result of the chemical's high volume of use and its tendency to persist and move with water, atrazine is one of the most frequently detected pesticides in sources of surface water (lakes, streams, and rivers) and groundwater (wells). The major source of exposure to concentrations of atrazine and the chlorotriazine metabolites is through drinking water in specified community water system (CWS) using surface water, and in rural wells located in atrazine use areas. CWS using surface water with some of the highest concentrations have been identified in the Midwest region of the U.S. in Illinois, Iowa, Missouri, and Indiana where the majority of the chemical is used on corn. However, Kentucky, Ohio, and Louisiana also had some of the CWS with the highest concentrations of atrazine and the chlorinated metabolites. CWS using groundwater do not have the high levels of atrazine monitored in rural wells and CWS using surface water.

Based on the data analyzed in this assessment, localized seasonal pulses of chlorotriazines in specific CWS using surface water in the Midwest corn belt is a major source of exposure from drinking water. These seasonal pulses are believed to occur shortly after application of atrazine in the spring, and generally occur from April through July. An analysis of the CWS with the highest concentrations identified to date indicate that seasonal pulses of atrazine and the chlorinated metabolites may occur from early spring, through summer, and into the fall. The higher concentrations occurring in the spring and summer influence the average concentrations all year long. HED notes that although data on CWS using surface water in states with high atrazine use have been considered, data on all CWS have not been assessed.

Additional exposures through dermal contact or incidental oral exposures associated with lawn and golf course treatments may also occur. Exposures through food are minimal.

Risk Assessments and Populations Considered

Risk assessments included in this document are: (1) an acute dietary assessment; (2) a chronic dietary assessment; (3) a short-term assessment based on nonoccupational (residential) exposures to atrazine, *per se*, of less than 30 days; and (4) short- and intermediate-term assessments of occupational exposures to atrazine, *per se*, under various use scenarios. Atrazine's chlorinated metabolites are: desethyl atrazine, desisopropyl atrazine, and diaminochlorotriazine (DACT). Residues of atrazine and these metabolites will be referred to as atrazine and the chlorinated metabolites and/or chlorotriazines.

The acute dietary risk assessment aggregates exposures to residues of atrazine and the chlorinated metabolites in food and drinking water. It combines a distributional analysis of one-day exposures to atrazine and the chlorinated metabolites in food with a screening-level analysis of high-end one-day exposures to atrazine and the chlorinated metabolites in drinking water. Under the acute dietary risk assessment, “females 13 to 50 years old” is the only relevant population subgroup considered. The toxicity endpoint of concern is based on developmental effects (delayed ossification) resulting from exposure of the fetus either *in utero* or through lactation. An appropriate toxicity endpoint of concern attributable to a single exposure was not identified for the general population, including infants and children. This indicates that although there is exposure, there is no concern for a direct acute hazard for these population subgroups.

Separate chronic dietary risk assessments were conducted for: (i) atrazine and the chlorinated metabolites; and (ii) the hydroxylated atrazine metabolites. For atrazine and the chlorinated metabolites, the toxicological endpoint of concern is disruption of hypothalamic function, as evidenced by attenuation of the preovulatory luteinizing hormone surge. For the hydroxy-metabolites, the endpoint of concern is kidney lesions. These assessments include all population subgroups (i.e., the general population including infants and children; a separate endpoint of concern was not identified for females of child bearing age). The chronic dietary risk assessment for atrazine and the chlorinated metabolites aggregates combined exposures to residues of atrazine and the chlorinated metabolites in food and drinking water. It combines average exposures to atrazine and the chlorinated metabolites in food with a deterministic and/or probabilistic analysis of seasonal (90-day average) and average annual exposures to atrazine and the chlorinated metabolites in drinking water. The same toxicologic endpoint was selected for intermediate-term and chronic risk assessments. The effect on which the endpoint is based is dose-dependent, i.e., lower doses requiring a longer time (months) and higher doses requiring a shorter time (days to weeks) to effect. Exposures to atrazine in drinking water span the intermediate-term (30 days to six months) and chronic (six months to lifetime) exposure time frames through seasonal and annual exposures. Therefore, both of these exposure periods, seasonal representing intermediate-term exposures in drinking water, and annual representing chronic exposures in drinking water, have been included under the chronic dietary risk assessment.

An appropriate toxicity endpoint of concern for hydroxy atrazine attributable to a single exposure was not identified for the general population, including infants and children. Because a toxic endpoint for chronic effects of hydroxyatrazine was determined that is distinct from the toxic endpoints determined for atrazine and the chlorinated metabolites, a separate chronic dietary risk assessment for exposures to the hydroxylated metabolites of atrazine in food only was conducted and included in this assessment. The risk assessment for the hydroxy-metabolites of atrazine included food as the only exposure pathway, because exposures to the hydroxy compounds are not expected to be significant in drinking water relative to exposures to atrazine and the chlorinated compounds as the hydroxy-metabolites are predominantly plant metabolites. Residue data on the hydroxy compounds in finished drinking water were limited.

Short-term residential exposures to atrazine, *per se*, are anticipated based on its registered use pattern. A risk assessment combining short-term oral, dermal, and inhalation residential exposures was conducted, as well as, a short-term aggregate risk assessment combining short-term (one to 30 days) residential exposures to atrazine, *per se*, with dietary (food and drinking water) exposures. Short-term exposures for adults handling and applying atrazine products, and for adults and toddlers exposed to atrazine and the chlorotriazine metabolites after application to turf (postapplication exposures) are included.

Intermediate-term exposures (30 days to six months) to atrazine resulting specifically from residential uses are not anticipated; therefore, an intermediate-term risk assessment inclusive of residential exposures was not conducted for atrazine. Chronic exposures (six months to lifetime) to atrazine as a result of residential uses are not anticipated; therefore, a risk assessment for chronic residential exposures was not conducted. The chronic aggregate risk assessment includes only those exposure pathways relevant for chronic exposure, i.e., food and drinking water as described above.

Separate occupational risk assessments based on short-term (one to 30 days) and intermediate-term (30 days to several months) dermal and inhalation exposures to atrazine, *per se*, are included for handlers applying atrazine products, and for postapplication exposures of harvesters. Where appropriate dermal and inhalation exposures were combined in the occupational risk assessments.

Atrazine's Primary Toxic Effects and Endpoints Identified for Risk Assessment

In the risk assessments presented here, atrazine's chlorinated metabolites are considered to be equivalent in toxicity to atrazine, *per se.* The toxic effects attributed to the hydroxy-metabolites of atrazine are considered to be independent of the effects of atrazine, *per se.* Consequently, risks associated with exposure to these hydroxylated compounds have been assessed separately.

Acute Effects

Atrazine and the Chlorinated Metabolites. The endpoints selected as the basis for acute risk assessment: reduced body weight gain in the dams, and delayed ossification in offspring, supported by decreased suckling-induced prolactin release and increased incidences of prostatitis in the male offspring, are based on three developmental studies. Two studies were conducted with rats, one with rabbits, and a fourth study that examined the effects of maternal exposure to atrazine during lactation on prostate effects in male suckling offspring. Based on the results of these four studies, a weight-of-the-evidence approach was used to select the dose and effects observed after the test animals received one-day exposures to atrazine in their diets. These effects are the basis of the acute (one-day) reference dose (aRfD) of 0.10 mg/kg/day, which is used to assess risks associated with acute dietary exposures. These effects have been identified as relevant for females 13 to 50 years old because the developmental effects on which this endpoint is based (delayed ossification in the offspring and prostatitis in the male) occurred only through maternal exposure, i.e., *in utero* via a pregnant female or via lactation, rather than through direct exposure of the offspring.

Hydroxyatrazine. A toxicological endpoint attributable to one-day exposures to hydroxyatrazine in the diet could not be identified. Therefore, a risk assessment for acute exposure to hydroxyatrazine was not conducted.

Short-Term Effects

Atrazine and the Chlorinated Metabolites. For assessing the short-term (one to 30 days) risks from incidental oral, dermal, and inhalation exposures, the HIARC selected the developmental no observed adverse effect level (NOAEL) of 6.25 mg/kg/day based on delayed puberty (delayed preputial separation) in male rats as the endpoint. This effect was seen in male rat offspring dosed for 30 days at the lowest observed adverse effect level (LOAEL) of 12.5 mg/kg/day in a study conducted by the EPA's Office of Research and Development's National Health and Environmental Effects Research Laboratory (NHEERL) study, and is considered evidence of altered hypothalamic-pituitary function, which can potentially broadly affect an individual's functional status. This endpoint is considered relevant and applicable to humans of all population subgroups, and considered protective of all populations.

Hydroxyatrazine. In a developmental toxicity study in the rat, decreased food consumption and renal effects were noted in the dams at 125 mg/kg/day. The NOAEL of 25 mg/kg/day was selected for risk assessment.

Intermediate-Term and Chronic Effects

Atrazine and the Chlorinated Metabolites. Atrazine decreases the hypothalamic gonadotrophin releasing hormone (GnRH) release in rats. There are also some data that indicate that atrazine diminishes norepinephrine in the rat hypothalamus as an initial or early site of action which in turn leads to diminished GnRH release. Atrazine also increases dopamine levels which can result in a diminished pituitary secretion of prolactin. Therefore, atrazine appears to operate at the level of the hypothalamus. In both humans and rats, hypothalamic GnRH controls pituitary hormone secretion (e.g., luteinizing hormone (LH), and prolactin (PRL). The hypothalamic-pituitary axis is involved in the development of the reproductive system, and its maintenance and functioning in adulthood. Additionally, reproductive hormones modulate the function of numerous other metabolic processes (i.e., bone formation, and immune, central nervous system (CNS) and cardiovascular functions). Therefore, altered hypothalamic-pituitary function can potentially broadly affect an individual's functional status and lead to a variety of health consequences.

The report for the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) Scientific Advisory Panel (SAP) meeting convened in June 2000 to consider the health consequences of exposure to atrazine, indicated that "..it is not unreasonable to expect that atrazine might cause adverse effects on hypothalamic-pituitary function in humans." Therefore, atrazine's effect on ovarian cycling and the preovulatory LH surge (as well as its effects on pregnancy, puberty, suckling induced PRL release which leads to prostatitis) are viewed as neuroendocrinopathies or biomarkers indicative of atrazine's ability to alter hypothalamic-pituitary function in general. It should be noted that atrazine's neuroendocrine effects have been demonstrated in several strains of rats (SD, Long Evans, and Wismar).

Attenuation of the luteinizing hormone (LH) surge, considered a biomarker indicative of atrazine's ability to alter hypothalamic-pituitary function, and estrus cycle disruptions demonstrated in female rats (e.g., Sprague-Dawley and Long Evans) is the basis of the chronic reference dose (cRfD) of 0.018 mg/kg/day, and is used to assess risks associated with chronic dietary exposures, and intermediate-term and long-term oral incidental, dermal, and inhalation exposures. Alteration of the hypothalamic-pituitary function as evidenced through the attenuation of the LH surge was dose-dependent and observed between four to five months of daily dosing in a six month study, making this endpoint an appropriate endpoint to assess intermediate-term (30 days to six months) and chronic (six months to lifetime) exposures to atrazine. Although this specific effect (attenuation of the LH surge) is operative in females, it was selected as the basis for intermediate-term and chronic risk assessment for all population subgroups, because it is the most sensitive endpoint available from the toxicity database and therefore protective of other adverse effects, and it is indicative of alterations of the hypothalamic/pituitary/gonadal axis, which may occur in the offspring and adults.

This endpoint is particularly appropriate for assessing intermediate-term and chronic exposures to atrazine in drinking water, as these exposures occur both as seasonal pulses from weeks to months in duration, and chronically from months to years in duration, reflective of atrazine's use patterns and occurrence in drinking water.

<u>Hydroxyatrazine</u>. In a combined chronic/carcinogenicity study conducted with Sprague-Dawley (BR strain) rats, both male and female rats exhibited gross and histopathological effects in the kidneys after exposure to hydroxyatrazine. A chronic RfD of 0.01 mg/kg/day was derived from this endpoint for chronic dietary risk assessment.

Carcinogenic Effects

Atrazine and the Chlorinated Metabolites. The Agency's FIFRA Scientific Advisory Panel (SAP), convened in June 2000, determined that the mode of action for the carcinogenic potential in the Sprague-Dawley rat is not likely to be operative in humans. HED's Cancer Assessment Review Committee (CARC) concurred with the SAP, also concluding that the mode of action is not relevant to humans. This conclusion was based on the following considerations: though hypothalamic disruption of pituitary function (i.e., attenuation of the LH surge) and resulting estrus cycle disruption may be occurring in humans following atrazine exposure, the hormonal environment resulting from these events would be expected to be much different from the hormonal environment seen in the rat. The prolonged/increased exposure to estrogen and prolactin as seen in the rat would not be expected to occur in humans. The prolonged/increased exposure to estrogen and prolactin in the rat is the basis of early-onset and increased mammary tumors in susceptible strains of rats. Additionally, the mutagenicity database is quite extensive and indicates that atrazine is not mutagenic. Consequently, in accordance with the *1999 Draft Guidelines for Carcinogen Risk Assessment*, the CARC classified atrazine “not likely to be carcinogenic to humans.” Therefore, a cancer risk assessment was not conducted for atrazine. However, as stated above, the SAP also concluded that....”it is not unreasonable to expect that atrazine might cause adverse effects on hypothalamic-pituitary function in humans.” Exactly what those effects in humans might be can only be deduced from the animal studies as previously described.

Hydroxyatrazine. No treatment-related increases in incidences of tumors of any type was observed in the treated male or female animals in the combined chronic/carcinogenicity study conducted with Sprague-Dawley (BR strain) rats. In particular, there was no increase above control levels in the incidence of mammary gland tumors in either males or females. In addition, onset times for mammary gland tumors in female rats were not decreased in this study. Therefore, a cancer risk assessment was not conducted for hydroxyatrazine.

FQPA Considerations

Atrazine and the Chlorinated Metabolites. The FQPA SFC recommends that OPP use the default 10X FQPA Safety Factor to protect the safety of infants and children in assessing dietary exposures to Atrazine; and that a 3X Special FQPA Safety Factor is adequate to protect the safety of infants and children in assessing residential exposures to Atrazine.

The 10X FQPA safety factor is being applied across all aggregate risk assessments based on estimated dietary exposures for all populations considered in these risk assessments. The 3X FQPA safety factor is being applied across all aggregate risk assessments based on estimated residential exposures for all populations considered in these risk assessments.

As per the Office of Pesticide Program's (OPP's) policy, a reference dose (RfD) modified by an FQPA safety factor is referred to as a population adjusted dose (PAD). As a FQPA safety factor was retained as 10X for dietary exposure, an acute PAD of 0.01 mg/kg/day, and a chronic PAD of 0.0018 mg/kg/day were used to estimate risk in the assessments based on acute and chronic aggregate exposures, inclusive of food and drinking water, respectively. For residential exposures a target MOE of 300 reflects an FQPA safety factor of 3X.

Hydroxyatrazine. The FQPA Safety Factor Committee following review of the hazard and exposure (food, water and residential) data recommended that the FQPA safety factor be removed (1x) when assessing the hydroxy-metabolites.

As per the Office of Pesticide Program's (OPP's) policy, a reference dose (RfD) modified by an FQPA safety factor is referred to as a population adjusted dose (PAD). As a FQPA safety factor was reduced to 1X for hydroxyatrazine, the chronic RfD and chronic PAD are equal, and a chronic PAD of 0.01 mg/kg/day was used to estimate risk in the assessments based on chronic exposures to hydroxyatrazine through food, only.

Risk Estimates for Dietary (Food Only) Exposures to Atrazine

HED's Metabolism Assessment Review Committee (MARC) has determined that the residues of concern for acute dietary risk are: atrazine and the chlorinated metabolites. The MARC has also determined that the residues of concern for chronic, noncancer dietary risk are: (i) atrazine and the chlorinated metabolites, and (ii) combined free hydroxy-metabolites. Separate chronic RfDs have been identified for each of these sets of residues for the purposes of dietary exposure assessment. Therefore, acute and chronic dietary exposure and risk assessments have been conducted for the combined residues of atrazine and the chlorinated metabolites. Because the HIARC assigned a separate chronic toxicological endpoint (and chronic RfD) to hydroxyatrazine, a chronic dietary risk assessment based on food exposures, only, has been conducted for the combined residues of atrazine's four hydroxylated metabolites. All four compounds are assumed to have the same toxicological effect and their combined residues have been compared to the endpoint specific to hydroxyatrazine in a separate risk assessment. No acute toxicological endpoint was identified for hydroxyatrazine.

Risk estimates are presented in this document as percentages of the PAD. Risk estimates for acute exposures less than 100% of the acute PAD and chronic exposures less than 100% of the chronic PAD are below HED's level of concern. Risk estimates do not exceed HED's level of concern, i.e., are less than 100% of the acute PAD or chronic PAD, for either acute exposures or chronic exposures to residues of atrazine in food for any of the relevant population subgroups analyzed. Risk estimates for one-day exposures in food to combined residues of atrazine and its chlorinated metabolites are less than 1% of the acute PAD for the relevant population subgroup, females 13 to 50 years old. The risk estimates for acute dietary exposures through food are based on a probabilistic assessment using distributional data on dietary consumption and body weights with anticipated residues on foods incorporating percent of the crop treated data. Distributions of monitoring data for food residues where available were used as appropriate. Risk estimates for average exposures in food to combined residues of atrazine and its chlorinated metabolites are less than 1% of the chronic PAD for all population subgroups analyzed. The risk estimates for chronic dietary exposures through food are based on a screening-level assessment using point estimates of average dietary consumption, average body weights, with average residues of atrazine and the chlorinated metabolites in foods, and incorporating percent of the crop treated data.

Average exposures to the hydroxy-metabolites of atrazine in food do not exceed HED's level of concern for chronic effects for all relevant populations included in the analysis. A separate risk assessment for exposures to hydroxy-metabolites of atrazine in food indicate that all risk estimates are less than 1% of the chronic PAD for hydroxyatrazine. Estimated exposures to the hydroxy-metabolites of atrazine in food, though still minimal, are marginally greater than estimated exposures to atrazine and the chlorinated metabolites in food. This is expected as the hydroxy-metabolites are the dominant plant metabolites of atrazine.

Risk Estimates for Dietary (Drinking Water) Exposures to Atrazine

Risk estimates associated with drinking water presented here are based on exposures to combined residues of atrazine and the chlorinated metabolites. These are the residues of atrazine expected to occur in drinking water in significant quantities, and monitoring data though limited for the chlorinated metabolites were available for these compounds in finished drinking water. A separate qualitative assessment of exposure to the hydroxy-metabolites of atrazine in drinking water is included in the drinking water risk assessment. Although data on the hydroxy-metabolites in drinking water were limited, exposure to these compounds in drinking water is expected to be significantly less than exposure to atrazine and the chlorinated metabolites.

Risk estimates for exposures to residues of atrazine and the chlorinated metabolites in drinking water have been provided for populations receiving their drinking water from: (i) community water systems (CWS) using surface water; (ii) CWS using groundwater; and (iii) individual rural wells located in atrazine use areas. There are approximately 11,400 CWS using surface water in the U.S. Exposure assessments (screening-level and/or probabilistic) were conducted for ~33 percent of these CWS serving approximately 65 million people. In total, 3670 CWS using surface water with monitoring data on atrazine in 21 major use states were assessed. There are a total of 43,607 public supply CWS using groundwater in the U.S. Exposure assessments (screening-level) were conducted for ~33 percent of these CWS serving approximately 55 million people. In total, 14,500 CWS using groundwater with monitoring data on atrazine in 21 major use states were assessed. The 21 major use states represent 92 percent of atrazine use in the U.S. Approximately 10 percent of the U.S. population receives their drinking water from rural wells, cisterns or springs, which are not regulated under the SDWA.

HED has considered the available data on concentrations of atrazine and the chlorotriazine metabolites in drinking water inclusive of treatment effects, if treatment was used, i.e., HED used monitoring data for finished drinking water in these risk assessments.

HED initially estimated risks using a screening-level approach to the available data. Under this approach specific CWS have been identified as having concentrations of atrazine and the chlorinated metabolites of potential concern. Under each risk assessment conducted for drinking water exposures: acute, intermediate-term, and chronic, if CWS were identified as of concern, they were assessed probabilistically to refine the risk estimates determined under the screening-level approach. Insufficient data were available to assess the population of rural wells probabilistically.

Risk Estimates for Acute (one-day) Exposures to Atrazine and the Chlorinated Metabolites in CWS using Surface Water

Based on a screening-level assessment for 3670 CWS in 21 states with high atrazine use, the measured maximum one-day concentrations of chlorotriazines in drinking water do not exceed HED's level of concern for acute effects, regardless of source, for the relevant population subgroup, females 13 to 50 years old. Under HED's screening-level approach to estimating aggregate risk from exposures to measured residues of atrazine plus estimates of the chlorinated metabolites in drinking water, one-day concentrations of residues of atrazine and the chlorinated metabolites less than 298 ppb do not exceed HED's level of concern for acute effects. Based on a variety of databases containing drinking water residue data for atrazine, the maximum measured concentration of atrazine plus an estimation of the chlorinated metabolites in any CWS monitoring for atrazine between 1993 and 2000 under the SDWA was 89 ppb. Based on the available data, HED does not expect one-day concentrations of chlorotriazines to exceed 298 ppb.

This value (298 ppb) is the drinking water level of comparison value for acute effects (acute DWLOC) for females 13 to 50 years old, and was calculated based on a 99.9th percentile food exposure for this subgroup of 0.000041 mg/kg/day, a 60 kg body weight, a 2L/day drinking water consumption rate, and an acute PAD of 0.01 mg/kg/day. It represents the one-day (maximum) concentration of residues of atrazine and the chlorinated metabolites in drinking water that is not expected to result in adverse acute health effects after considering one-day exposures to residues of atrazine and the chlorinated metabolites in food at the 99.9th percentile of exposure.

Risk Estimates for Intermediate-Term (seasonal) and Chronic (annual) Exposures to Atrazine and the Chlorinated Metabolites in CWS using Surface Water

Risk estimates based on estimated 90-day average exposures to atrazine and the chlorinated metabolites indicate that 29 CWS out of 3670 assessed have had seasonal exposures that exceed HED's levels of concern for infants at the maximum 99.9th percentile of exposure in one, two, or three years between the period 1993 to 2001. Risk estimates for these CWS range from 100% to 670% of the cPAD. Eleven of these CWS have also had annual average exposures that exceed HED's levels of concern for infants. Several of these CWS also exceed levels of concern at the maximum 99.9th percentile of exposure for children aged one to six years of age, and adults as well. These 29 CWS are: Gillespie, Hettick, Salem, Palmyra-Modesto, Hillsboro, Farina, Kinmundy, ADGPTV, Carlinville, West Salem, Flora, Sorento, White Hall, Louisville, and Centralia in Illinois, Chariton in Iowa, Iberville in Louisiana, Batesville, Holland, North Vernon, and Scottsburg in Indiana, Lewisburg and Marion in Kentucky, Bucklin, Dearborn, Drexel, and Vandalia in Missouri, Newark, and Sardinia in Ohio. They serve approximately 180,000 people of which 6.8 percent (2000 Census) are five years old or younger, and 1.4 percent are one year old or less.

An additional 52 CWS have been identified for targeted monitoring because they had high quarterly maximum concentrations of the chlorotriazines. (See Additional Concerns section below.)

Risk Estimates for Acute (one-day) and Chronic Exposures in CWS using Groundwater

Risk estimates based on screening-level assessments for 14,500 CWS using groundwater (~33 percent of groundwater CWS in the U.S.) do not exceed HED's level of concern for acute or chronic effects. Previously, HED concluded that CWS using groundwater are not impacted nearly as heavily by atrazine use as CWS using surface water and rural wells. This was based on a partial assessment (contained in the revised preliminary human health risk assessment 1/19/01) that used the available compliance monitoring data collected under the SDWA on residues of atrazine, *per se*, in finished drinking water. The MCL (3 ppb) was compared to the available monitoring data. No data on the chlorinated metabolites was available at that time.

Since that time, data to estimate concentrations of the chlorinated metabolites of atrazine in these CWS have been developed. The registrant supplied a synoptic survey of CWS using groundwater in 21 major atrazine use states. The highest concentration of atrazine and the chlorinated metabolites measured in any well in the survey was ~11 ppb. The 99th percentile concentration value for chlorotriazines in CWS with prior detections of atrazine was 1.9 ppb. Both the maximum measured value and the 99th percentile value are less than the acute DWLOC of 298 ppb, and do not exceed HED's level of concern for acute effects. Because a 95 percent upper confidence bound around the 99th percentile value was not estimated, there is uncertainty that an estimate of the maximum chlorotriazine concentration in groundwater CWS has been made. However, HED notes that approximately 50 percent of the groundwater CWS with prior detections of atrazine have been sampled, and therefore HED has high confidence that exposures to atrazine and the chlorinated metabolites do not exceed HED's level of concern (298 ppb) in CWS using groundwater. The 50th percentile concentration value was 0.180 ppb for CWS with prior detections. The mean concentration value at the 95 percent upper confidence bound was 0.55 ppb for CWS with prior detections. Both are less than the lowest intermediate-term to chronic DWLOC of 12.5 ppb, and do not exceed HED's level of concern for chronic effects.

The 418 CWS using groundwater with prior detections of atrazine represent ~3 percent of the 14,500 groundwater CWS in the 21 major atrazine use states that are monitoring for atrazine. In contrast, approximately 41 percent of CWS using surface water in the 21 major use states that are monitoring for atrazine had detections of atrazine in finished drinking water. Although this synoptic survey for CWS using groundwater is considered incomplete until further statistical analyses are performed on the study data, in general, the results support HED’s previous conclusion that CWS using groundwater are not impacted as heavily by atrazine use as CWS using surface water and rural wells.

Risk Estimates for Acute (one-day) and Chronic Exposures to Atrazine and the Chlorinated Metabolites in Domestic Rural Wells used for Drinking Water

Based on the data available, acute (one-day) exposures to atrazine and the chlorinated metabolites in drinking water from rural wells do not exceed HED’s level of concern. Chronic exposures of adult populations using rural wells for drinking water also do not exceed HED's level of concern. HED has concerns for chronic exposures of the subpopulation of infants and children getting their drinking water from rural wells located directly in atrazine use areas, i.e., adjacent to fields where atrazine was used. Eight wells out of the 1,505 wells selected based on their location in areas with high atrazine use were tested and had residues of atrazine and the chlorinated metabolites approaching, equal to, or greater than 12.5 ppb. These eight wells were resampled in March 2001, one sample per well. All samples showed concentrations of atrazine and the chlorinated metabolites less than 12.5 ppb. Although the data indicate that levels are decreasing in these wells over time, there are still concerns for subchronic and chronic exposures of infants using private rural wells in close proximity to atrazine use areas. It is difficult to interpret typical exposures in rural wells close to atrazine use areas based on two samples taken many years apart.

Because there are approximately 13 million “household” wells in the U.S.[1], the rural well survey (including 1,505 wells) is inadequate to fully assess exposures to the population in the U.S. using rural wells for drinking water. In addition, because only one sample per well was taken and analyzed, HED has high uncertainty regarding exposures to atrazine and the chlorotriazine metabolites for the population using rural wells for drinking water.

Additional Concerns

HED has identified 52 additional CWS using surface water with maximum

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[1]Van der Leeden, F., et al., The Water Encyclopedia, 2nd ed., Geraghty & Miller Ground-Water Series, Lewis Publishers, Michigan, 1990.

measured concentrations of atrazine and estimations of the chlorinated metabolites equal to, or greater than 12.5 ppb (the intermediate-term to chronic DWLOC value) for infants and children's groups, but with annual average concentrations below 12.5 ppb that were not included in the more intensive sampling programs sponsored by industry. There are no seasonal mean concentrations for these CWS, only maximum and annual average concentrations. These CWS may have seasonal mean concentrations either above or below intermediate-term and chronic DWLOC values. Although a direct comparison of these maximum measured concentrations to 12.5 ppb would be inappropriate, this finding introduces a source of uncertainty into this risk assessment as it cannot be known from the available data if these CWS have seasonal mean concentrations of atrazine and the chlorotriazine metabolites resulting in exposures and risk estimates above HED's level of concern. These CWS are listed in Appendix III for OPP's use in mitigation and the OW's use in consideration of any necessary actions for these CWS.

Risk Estimates Associated with Residential Exposures to Atrazine

Risk estimates for residential exposures to atrazine consider exposure to atrazine, *per se*, because only the parent compound is expected to be available for exposure on the surfaces of the foliage treated, and monitoring data were collected for the parent compound only. Residues of the chlorinated and hydroxylated metabolites are not expected on plant surfaces. Dermal, dietary (food and drinking water), and inhalation exposures have been combined as appropriate for adults. Dermal, dietary (food and drinking water), and incidental oral exposures have been combined as appropriate for children.

Risk estimates for residential exposures to atrazine are expressed as Margins of Exposure (MOEs) which are the ratio of the NOAEL to estimates of exposure. Residential exposure scenarios with MOEs greater than 300 do not exceed HED's level of concern. Risk estimates for combined short-term (one to 30 days) residential dermal and inhalation exposures for adult handlers applying atrazine to lawns were estimated using HED's Standard Operating Procedures for Estimating Residential Exposures (Residential SOPs) and available Occupational and Residential Exposure Task Force (ORETF) data. Risk estimates do not exceed HED's level of concern; i.e., all MOEs for all exposure scenarios are greater than 300, except for the application scenario for belly-grinders and granular formulations applied over 0.5 acres (MOE of 65). Intermediate-term exposures, greater than 30 days in duration, are not expected to result from adult handlers applying atrazine to lawns; therefore, risk assessments for intermediate-term residential exposures for adult handlers were not conducted.

Short-term residential post application risk estimates do not exceed HED's level of concern for adults or children exposed dermally while playing on lawns immediately after treatment with liquid or granular formulations of atrazine, unless the turfgrass is wet. Liquid formulations applied to turfgrass that is wet result in MOEs for children and adults playing on turf one day after treatment of 110 and 190, respectively. After the 2nd day, MOEs are above 300 for both children and adults under this exposure scenario.

Risk estimates for toddlers' short-term exposures to atrazine through incidental oral exposures exceed HED's level of concern. The risk estimate (MOE) for children mouthing their fingers after contact with turfgrass treated with liquid formulations was 210, while children mouthing their fingers after a treatment of turfgrass with granular formulations resulted in a MOE of 940. Mouthing grass and ingesting soil treated with either liquid or granular formulations result in MOEs of 3300 and 62,000, respectively.

The aggregation of all of these mouthing activities (mouthing fingers + mouthing grass + soil ingestion) based on liquid and granular formulations result in MOEs of 190 and 730, respectively. Combined dermal and incidental oral exposures of toddlers exceed levels of concern. MOEs for incidental oral exposures for toddlers range from 16 to 110 for granule ingestion exposure scenarios. Granular ingestion is considered an episodic event and is not aggregated with other incidental oral exposures. Intermediate-term post application residential exposures, greater than 30 days in duration, are not expected as a result of residential uses of atrazine; therefore, risk assessments for intermediate-term post application residential exposures were not conducted.

Aggregate Risk Estimates for Acute, Short-Term, and Intermediate-Term to Chronic Exposures to Atrazine Through the Diet, Drinking Water, and Residential Use

The aggregate risk assessments presented in this document estimate risks associated with combined exposures to concentrations of atrazine and the chlorotriazine metabolites through multiple exposure pathways, specifically, through combining residues of atrazine and the chlorinated metabolites in food and drinking water (dietary), with residues of atrazine, *per se*, from home uses. As previously stated, residues of atrazine and the chlorinated metabolites are considered toxicologically equivalent and are expected to occur in food and drinking water simultaneously, and exposures to residues of atrazine, *per se*, are expected on grasses from residential uses. Exposure to atrazine's chlorinated metabolites is not expected to occur from contact with plant surfaces. Under HED's interim approach to incorporating drinking water exposures into estimates of aggregate risk, an exposure scenario exceeds HED's level of concern when measured concentrations of atrazine and the chlorinated metabolites are greater than the DWLOC values calculated for specific population subgroups.

Exposures to hydroxyatrazine were considered for the food exposure pathway, only, and were not aggregated quantitatively with exposures through any other pathway for the following reasons: (1) residues of hydroxyatrazine are expected to form in the most significant quantities once absorbed and metabolized in plant tissues; (2) residues are not expected to form on plant surfaces; (3) residues are formed to a lesser extent than the chlorinated metabolites in water; and (4) monitoring data on these compounds in finished drinking water were limited.

Acute Aggregate Risk Estimates

The aggregate risk assessment for acute exposures to atrazine and the chlorinated metabolites combines high-end, one-day exposures through food and drinking water, only. Exposure to atrazine from food sources (based on 99.9th percentile exposure estimates) and drinking water (based on surface and groundwater monitoring data on finished drinking water) do not exceed HED's level of concern for acute dietary risk for the relevant subgroup, females 13 to 50 years old.

Aggregate Risk Estimates Acute (one-day) Exposures to Combined Residues of Atrazine and the Chlorinated Metabolites

Exposure Pathway	Population Assessed	Risk Estimates
Food	Females 13 to 50 years old	< 1% acute PAD
Food + Drinking water	Females 13 to 50 years old	Maximum measured concentrations of chlorotriazine residues in drinking water (89 ppb) are below DWLOC value (298 ppb) for acute effects in all CWS assessed and rural wells. No acute risk concerns.

Aggregate Risk Estimates for Intermediate-Term to Chronic Effects

The aggregate risk assessment for intermediate-term to chronic exposures to atrazine and the chlorinated metabolites combines estimates of high-end seasonal (intermediate-term) or annual average (chronic) exposures to atrazine through drinking water with long-term average exposures through food. Intermediate-term (30 days to six months) and chronic (six months to lifetime) exposures are not expected to occur from residential uses of atrazine. Therefore, aggregate risk assessments inclusive of intermediate-term and chronic residential exposures were not conducted, and the intermediate-term and chronic aggregate risk estimates are the same as those summarized above for intermediate-term and chronic drinking water risks. In total, 29 CWS using surface water had risk estimates (based on seasonal exposures to atrazine and the chlorinated metabolites) exceeding HED's level of concern for infants. An additional 52 CWS have been identified for targeted monitoring.

In addition, eight rural wells out of 1,505 tested have concentrations of atrazine and the chlorinated metabolites above HED's level of concern for infants. These wells do not represent a national exposure for all individuals using rural wells for drinking water.

Aggregate Risk Estimates for Intermediate-Term (seasonal) and Chronic (annual) Exposures to Combined Residues of Atrazine and the Chlorinated Metabolites

Exposure Pathway	Population Assessed	Risk Estimates
Food	Infants (< 1 year old)	< 1% chronic PAD
	Children (1 to 6 years old)	< 1% chronic PAD
	Adults (females + males)	< 1% chronic PAD
Food + Drinking Water	Infants < 1 year old	>100% PAD for intermediate-term to chronic effects in 29 CWS using surface water based on annual and/or seasonal average chlorotriazine exposures in one, two, or three years from 1993 to 2001. Concern for some rural wells.
	Children 1 to 6 years old	>100% PAD for intermediate-term to chronic effects in some of the 29 CWS identified with infant exposures of concern. Concern for some rural wells.
	Adults (male + female)	>100% PAD for intermediate-term to chronic effects in some of the 29 CWS identified with infant exposures of concern. Concern for some rural wells.

Short-Term Aggregate Risk Estimates

For those regions of the U.S. where atrazine is used on home lawns (the Southeast), short-term aggregate risk estimates do not exceed HED's level of concern for adults applying atrazine products unless they use a belly-grinder and treat 0.5 acres or more at one time. Short-term aggregate risk estimates exceed HED's level of concern for postapplication exposures of adults and toddlers coming into contact with turf immediately after application of liquid formulations if the turf becomes wet. Because several of the residential short-term exposure scenarios for adults and children have risk estimates exceeding HED's level of concern based on either dermal and/or incidental oral exposures, alone, combining these exposures with additional dietary exposures (via food and drinking water) would result in risk estimates further exceeding HED's level of concern.

Aggregate Risk Estimates for Short-Term (one to 30 days) Exposures

Exposure Pathway	Population Assessed	Risk Estimates
Food + Drinking Water + Residential	Adults (males and females) applying atrazine	DWLOC values for short-term effects based on combined exposures from food, drinking water, and dermal pathways are greater than measured maximum, and estimated weekly, seasonal and annual average concentrations of chlorotriazine residues in drinking water for all exposure scenarios, unless a belly-grinder is used. Marginal risk concerns.
	Adults (males and females) post application	DWLOC values for short-term effects based on combined exposures from food, drinking water and dermal pathways are greater than measured maximum, and estimated weekly, seasonal and annual average concentrations of chlorotriazine residues in drinking water for all exposure scenarios except for dermal exposures on wet turfgrass immediately after application of liquid formulations. Marginal risk concern.
	Toddlers post application	DWLOC values for short-term effects based on combined exposures from food, drinking water, dermal and incidental oral pathways are less than measured maximum, and estimated weekly, seasonal and annual average concentrations of chlorotriazine residues in drinking water. Risk concerns based on oral incidental exposures after liquid formulation applications.

Risk Estimates Associated with Occupational Exposures to Atrazine

For short-term exposure estimates based on either PHED data, chemical specific exposure studies, and/or ORETF data, with appropriate PPE or engineering controls, all but three short-term aggregate (dermal and inhalation) handler exposure scenarios had MOEs greater than 100, and thus, do not exceed HED's level of concern. The dry fertilizer admixture (mixer/loader) scenarios exceed the level of concern for the highest estimated daily quantities handled. However, there is considerable uncertainty in this scenario due to a lack of data on fertilizer mixing, and the use of grain treatment as a surrogate. There were no exposure data for liquid/liquid fertilizer treatment, so risk estimates for this scenario could not be calculated.

For intermediate-term exposure estimates based on either PHED data, chemical specific exposure studies, or a combination of these data, with appropriate personal protective equipment (PPE) or engineering controls, most (approximately 85 percent) intermediate-term aggregate (dermal and inhalation) handler exposure scenarios had MOEs greater than 100, and thus, do not exceed HED's level of concern. There were no exposure data for liquid/liquid fertilizer treatment, so risk estimates for this scenario could not be calculated. Intermediate-term exposures that exceed HED's level of concern are generally associated with mixing and loading of the largest quantities (liquid or dry flowable/WDG) of atrazine. Examples include the higher application rates and acreage for use on chemical fallow lands, grasslands, corn, sorghum, and in fertilizer admixture.

Most of the atrazine used in agriculture is applied to corn and sorghum early in the season, either before weeds emerge (preemergence) or when the crops are quite small (generally less than 12 inches high). This fact, and the degree of mechanization in cultivating these crops, minimizes the post application contact of workers with the chemical on these crops. All but one of the post application short- and intermediate-term dermal risk estimates were below the HED's level of concern (range 68 to 1.4 million). The lowest MOE (68) was for scouting sugar cane, using the corn DFR data.

Uncertainties and Levels of Confidence Associated with These Risk Estimates

All risk estimates presented in this document conducted for dietary, drinking water, residential, and occupational exposures, using screening-level approaches, are considered to be conservative. The risk estimates for CWS assessed probabilistically for exposure to chlorotriazines in drinking water are considered to be refined. Major sources of uncertainty associated with each risk assessment are mentioned here, but all relevant sources of uncertainty are discussed under each specific risk assessment in detail.

Risk Estimates for Food Exposures

HED believes the risk estimates for acute (one-day) and chronic (average) exposures to residues of atrazine through food are conservative and health protective. The confidence associated with these risk estimates is high. The data available for dietary exposure assessment were of very high quality being either USDA's Pesticide Data Program (PDP) monitoring data or residue data from adequate field trials and plant and animal metabolism studies. All available monitoring, field trial, and metabolism study data on concentrations of atrazine and the chlorotriazine metabolites in plant and animal commodities were used to estimate anticipated residues for the majority of human food items included in the dietary assessments. Tolerance level residues representing the maximum residue expected to occur from labeled uses of atrazine were used for guava only. The best available information on the percentage of crop treated was also included. The acute dietary assessment used probabilistic techniques to estimate exposure.

Risk Estimates for Combined Drinking Water and Food Exposures

HED believes the risk estimates based on screening-level methodologies to assess exposures are conservative for the portion of the population receiving their drinking water from CWS using surface water. These exposures and risks have been estimated using a screening-level approach, in which, a single residue value, either a maximum value for acute effects, or 90-day and annual average values for intermediate-term to chronic effects, is assumed along with default drinking water consumption rates and body weights for each population subgroup considered in the assessment. HED has high confidence in the risk estimates based on probabilistic methodologies to assess exposures. HED also believes these risk estimates based on seasonal pulses of chlorotriazines to be conservative because maximum 90-day average concentrations were used to represent a seasonal average exposure period, and the relevant endpoint for intermediate-term and chronic effects (attenuation of the LH surge, considered a biomarker indicative of atrazine's ability to alter hypothalamic-pituitary function) is seen in the test animals after four to five months of daily exposure at 3.65 mg/kg/day (lowest observed adverse effect level from Morseth 1996b).

HED associates a moderate to high confidence with these risk estimates for CWS using surface water. The most recent changes to atrazine use rates should be reflected in these data. The data available for drinking water exposure assessment were extensive and of very high quality for atrazine, *per se*, but limited for the chlorinated metabolites. The 52 CWS identified in Appendix III introduce a source of uncertainty into the risk assessment for CWS using surface water as discussed above under the estimates of risk for exposures through drinking water. It cannot be known from the available data whether these CWS have seasonal average concentrations above a level of concern; however, there could be additional CWS that have seasonal mean concentrations of atrazine and the chlorinated metabolites that exceed HED's level of concern. The available drinking water monitoring data were assessed for ~33 percent of CWS (surface water and groundwater). Although these data represent higher-end exposures in major use states, HED cannot be certain that all CWS using surface water or blends of ground and surface water with exposures of concern have been identified.

HED has a high level of confidence with the estimates of risk for that portion of the population receiving their drinking water from CWS using groundwater. The majority of these CWS had no prior detections of atrazine, *per se*, and ~50 percent of those with prior detections in the highest use states were monitored for the parent plus the metabolites.

HED has a moderate to low level of confidence with the estimates of risk for that portion of the population receiving their drinking water from rural wells in close proximity to atrazine use areas. The wells selected for monitoring were chosen because of their location in atrazine use areas, and as such they represent a set of wells with potential high-end exposures rather than a set of wells representing the national exposure. However, only one sample was taken per well, and only 1,505 wells were sampled. HED does not know whether this one sample represents a maximum, a minimum, or some sort of average concentration value for concentrations of atrazine and the chlorotriazine metabolites in those wells, and HED is uncertain about the extent of exposure for populations on rural wells. This is a major source of uncertainty for the risk assessments conducted for rural wells.

Risk Estimates for Residential Exposures

Estimates of risk associated with residential use of atrazine products are based on average high-end residues, and standard operating procedures and assumptions that are considered to be conservative, screening-level assessments. The data available for residential exposure assessments were of high quality. HED associates a fairly high level of confidence with risk estimates for dermal postapplication exposures to atrazine; however, these risk estimates resulting in MOEs which exceed the Agency's level of concern are based on the highest reported residue levels from exposure studies, and are considered conservative. Toddler's incidental oral and granular ingestion exposure scenarios are based on standard assumptions and formulae (Residential SOPs, 1999) which are designed to provide screening-level estimates of exposure. Hand-to-mouth exposures from incidental oral ingestion of granules has been estimated from a chemical-specific study designed to provide refined estimates of exposure. HED's confidence in the risk estimates for these exposure scenarios is low to moderate. A probabilistic approach to the use of the various residue study data would help to refine the risk estimates.

Risk Estimates for Occupational Exposures

HED has a high confidence level in the occupational risk estimates. While uncertainty cannot be completely removed from any pesticide risk assessment, there is a substantial amount of actual field monitoring data for assessing the occupational exposures of handlers of atrazine in the largest area of use, field and row crops. Available studies support the handler exposure and risk estimates stated here, given that most of the estimates are for typical-to-high application rates and acres treated per day. Less data were available for most of the other crops and the fertilizer admixture scenarios assessed. A high level of confidence is associated with the risk estimates for postapplication exposures from field crops and turf as they are based on acceptable guideline field residue study data. Most of the remaining occupational postapplication risk estimates were extrapolated from those residue studies using the best available crop-specific transfer coefficients, and consequently, are considered more uncertain because of the translation of residue data from one crop to another.

Data Gaps

The available database is complete and of high quality and supports this revised human health risk assessment. There are no significant data gaps for residue and product chemistry, toxicology, dietary exposure assessment , and occupational and residential exposures. A limited field rotational crop study, additional information on trends of atrazine concentrations in water over time, and a one-year study in the rat on atrazine, simazine, and DACT have been submitted and are under review.

Additional data to refine and clarify the risk estimates presented in this document include: a study to assess CNS alterations after atrazine exposure (recommended); a 28-day inhalation toxicity study measuring LH surge and estrus cycle parameters; confirmatory storage stability data; field trial data to support a crop group tolerance for Crop Group 17 (Grass Forage, Fodder, and Hay Group); continued sampling of CWS currently included in the VMS program, and inclusion of the 52 CWS identified in Appendix III; additional sampling in rural wells in proximity to atrazine high-use areas; exposure and risk assessments for CWS using surface water or blended water in states with moderate to low atrazine use; and additional exposure data for mixing, loading, and application of dry and liquid fertilizers, both commercially (including cooperatives) and on-farm.

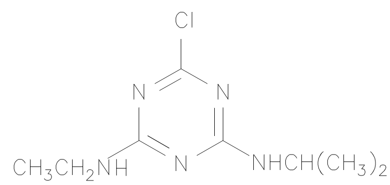
2.0 PHYSICAL/CHEMICAL PROPERTIES CHARACTERIZATION

Atrazine (2-chloro-4-ethylamino-6-isopropylamino-*s*-triazine) is a triazine herbicide. It is a systemic pesticide. There are no known isomeric forms or impurities of toxicological concern associated with this compound. Atrazine's chemical structure is provided below in Figure 1.

Figure 1. Chemical Name and Structure of Atrazine

Atrazine

2-chloro-4-ethylamino-6-isopropylamino-*s*-triazine



(G-30027)

Residues of atrazine are absorbed through the plant root system, and translocated throughout the plant. Concentrations of atrazine and the chlorotriazine metabolites are not expected to be removed through simple washing and peeling. However, foliar applications of atrazine appear not to be translocated from leaves to other parts of the plant. Atrazine acts by blocking photosynthesis in plants.

In general, atrazine is persistent and mobile in the environment. Atrazine resists abiotic (chemical) hydrolysis; it is stable at ambient pH, and resists aqueous photolysis. It is only moderately susceptible to degradation in soil with half-lives of three to four months in the laboratory under aerobic conditions. In anaerobic conditions, atrazine's half-life may be much longer with the water and sediment half-lives being 578, and 330 days, respectively. It is unlikely that atrazine degrades rapidly in soil, on plant foliage, or in water. Atrazine has a relatively low vapor pressure, and is not expected to volatilize rapidly from soil, foliage, or water. Atrazine is not strongly adsorbed to soil particles and organic matter; it partitions preferably into water, which may result in some volatilization from foliage. In addition, its relatively low adsorption characteristics indicate that atrazine may undergo substantial wash off from foliage. It should also be noted that foliar dissipation rates for numerous pesticides have generally been somewhat greater than otherwise indicated by their physical/chemical, and other fate properties.

These generalized physical/chemical properties affect the fate and transport of the compound and its availability in the environment in edible portions of plants, in water used for drinking, and on treated foliage. It is generally accepted that atrazine's relative persistence and mobility in the environment coupled with its widespread use on animal feed crops (corn) result in the frequent occurrence of atrazine in surface and groundwaters located in high use areas. This provides an opportunity predominantly for oral exposures to atrazine and the chlorinated metabolites via drinking water and through the transfer of residues in animal feeds to humans through the diet. Dermal exposures may be expected through the transfer of residues from foliage during and after applications of atrazine products. Although not expected to be a dominant exposure route, there is some possibility of inhalation exposures during application.

3.0 HAZARD CHARACTERIZATION

3.1 Hazard Profile

The toxicology database is extensive and there is a high degree of confidence in the scientific quality of the toxicity studies conducted with atrazine. Toxicity studies required under the Subdivision F Guidelines have been submitted and found acceptable by the Agency. Special studies examining the toxicology of atrazine have been performed by the registrant in addition to the required guideline studies. Additionally, EPA's National Health and Environmental Effects Laboratories (NHEERL) have performed studies investigating atrazine's neuroendocrine mode of action and related reproductive and developmental effects. These studies have been published in the peer reviewed literature. These numerous studies, taken together, define what is known to date about the toxicology associated with atrazine exposure.

Registrant-submitted studies demonstrating the endpoint selected for use in the intermediate-term and chronic risk assessments (attenuation of the luteinizing hormone (LH) surge and estrus cycle data) have been published in the open literature as well as being submitted to the EPA. There are not just one, but multiple registrant-submitted studies in which LH surge and estrus cycles are shown to be altered following atrazine exposure (four studies have been submitted demonstrating LH surge alterations and five studies have been submitted examining estrus cycle alterations). Finally, EPA's NHEERL research, which has been performed independently of the registrant-submitted data and published, demonstrate reproductive and developmental effects consistent with neuroendocrine alterations.

A summary table of each of the toxicity studies with the No Observable Adverse Effect Level (NOAEL), the Lowest Observable Adverse Effect Level (LOAEL), and the MRID numbers are presented in Appendix A. The data base for acute toxicity is complete and data on the technical product is tabulated below in Table 1. In general, has low acute toxicity (Categories III and IV).

Table 1. Acute Toxicity Data of Technical Atrazine

Guideline No.	Test	Results	Toxic Category
81-1	Oral LD_{50} - rat	LD_{50} >1,869 mg/kg (M&F combined)	III
81-2	Dermal LD_{50} - rat	LD_{50} >2,000 mg/kg (M&F combined)	III
81-3	Inhalation LC_{50} - rat	LC_{50} >5.8 mg/L (M&F combined)	IV
81-4	Eye Irritation - rabbit	Non irritant	IV
81-5	Dermal Irritation -rabbit	Non irritant	IV
81-6	Dermal Sensitization	Non-sensitizer	---

There is direct evidence that atrazine is associated with endocrine disruption. Direct measurements of norepinephrine, dopamine, and GnRH, and of serum hormones such as certain steroid hormones and luteinizing hormone, as well as changes in estrus cycling and histomorphic changes in hormone responsive tissues, indicate neuroendocrine disruption.

Atrazine appears to operate at the level of the hypothalamus. In both humans and rats, hypothalamic GnRH controls pituitary hormone secretion (e.g., luteinizing hormone (LH), prolactin). Atrazine decreases the release of hypothalamic gonadotrophin releasing hormone (GnRH) in rats. There are also some data that indicate that atrazine diminishes norepinephrine in the rat hypothalamus as an initial or early site of action which in turn leads to diminished GnRH release. Atrazine also increases dopamine levels which can result in a diminished pituitary secretion of prolactin. The hypothalamic-pituitary axis is involved in the development of the reproductive system, and its maintenance and functioning in adulthood. Additionally, reproductive hormones modulate the function of numerous other metabolic processes (i.e., bone formation, and immune, cental nervous system (CNS) and cardiovascular functions). Therefore, altered hypothalamic-pituitary function can potentially broadly affect an individual’s functional status and lead to a variety of health consequences.

The Scientific Advisory Panel convened in June 2000 to consider the health consequences of exposure to atrazine, indicated in their report that "..it is not unreasonable to expect that atrazine might cause adverse effects on hypothalamic-pituitary function in humans." Therefore, atrazine's effect on ovarian cycling and the preovulatory LH surge (as well as its effects on pregnancy, puberty, suckling induced PRL release which leads to prostatitis) are viewed as neuroendocrinopathies or biomarkers indicative of atrazine's ability to alter hypothalamic-pituitary function in general. It should be noted that atrazine's neuroendocrine effects have been demonstrated in several strains of rats (SD, Long Evans, Wistar).

A primary toxicologically significant effect is an attenuation of the proestrus afternoon luteinizing hormone (LH) surge which results in estrus cycle alterations and subsequent alterations in hormone levels. The no observed adverse effect level (NOAEL) for this effect was selected by the Hazard Identification Assessment Review Committee (HIARC) as the endpoint for risk assessments which incorporate chronic dietary exposure, and intermediate- and long-term dermal and/or inhalation exposures. This effect occurred consistently in assays conducted in the Sprague-Dawley strain of rat. The LH and estrus cycle effects have also been demonstrated in Long Evans rats, but did not occur in chronic studies conducted with the Fischer-344 strain of rat. The NOAEL of 1.8 mg/kg/day for the attenuation of LH surge seen at the LOAEL of 3.65 mg/kg/day was selected as the basis for establishing the chronic Reference Dose (or cRfD).

A dose-response relationship has been demonstrated for the attenuation of the LH surge in several special studies conducted by the registrant. This effect occurs in short-term (28-day), sub chronic (six month), and chronic (one to two year) studies. As would be expected where a causal dose-response relationship has been established, lower doses over a longer period of time are required to induce the same effects in long-term (chronic) studies compared to shorter term studies. Daily dosing at the lowest observed adverse effect level (LOAEL) of 3.65 mg/kg/day is necessary over a period of four to five months to elicit attenuation of the LH surge. Daily doses at higher levels elicit the response more quickly; attenuation of the LH surge was noted after three months of daily doses at 29 mg/kg/day, and after one month at daily doses of 40 mg/kg/day. Attenuation of the LH surge occurs normally in the Sprague-Dawley rat at nine months of age through the normal aging process in this strain of rat.

The attenuation of the LH surge is an integral part of the neuroendocrine mode of action pathway leading to the potential carcinogenicity in the Sprague-Dawley strain of rats. The neuroendocrine effects of atrazine (i.e., alterations in GnRH, dopamine, prolactin and LH) have also been shown to play a role in certain reproductive and developmental effects in rats. This mode of action identified for cancer-associated effects in the Sprague-Dawley (SD) rat are specific to rats whose mode of reproductive senescence is "constant estrus." These effects did not occur in F-344 strain of rat, and thus only appear to occur in the SD, Long-Evans or Wistar strains.

The attenuation of the LH surge and estrus cycle disruptions appears to be a species, strain and sex specific effect occurring in female Sprague-Dawley rats, and in some other rat strains with a similar reproductive aging pattern. The Agency's FIFRA Scientific Advisory Panel (SAP) convened in June 2000 determined that the mode of action for cancer-associated effects in the Sprague-Dawley rat is not likely to be operative in humans. HED's Cancer Assessment Review Committee (CARC) concluded that the mode of action is not relevant to humans. Although hypothalamic disruption of pituitary function (i.e., attenuation of the LH surge) and resulting estrus cycle disruption may be occurring in humans following atrazine exposure, the hormonal environment resulting from these events would be expected to be much different from the environment seen in the rat. The prolonged/increased exposure to estrogen and prolactin seen in the rat would not be expected to occur in humans. Consequently, in accordance with the 1999 Draft Guidelines for Carcinogen Risk Assessment, the CARC classified atrazine as “not likely to be carcinogenic to humans.” Therefore, a cancer risk assessment was not conducted for atrazine.

The HIARC determined that there is no qualitative or quantitative susceptibility of offspring and fetuses to atrazine/DACT exposures in the rat. In the two prenatal developmental toxicity studies in rats, developmental effects (delayed or (no) ossification at several sites) were seen in the presence of maternal toxicity at equivalent doses. There was no quantitative susceptibility in the rabbit, but qualitative susceptibility was demonstrated in the rabbit (increased resorptions (deaths) versus decreased body weights and clinical signs in the dams) following exposure to atrazine at equivalent doses. In the two generation reproduction study in rats, no offspring toxicity was seen in females; male offspring exhibited decreased body weight, which was seen in the presence of parental toxicity at equivalent doses. It should be noted that the two-generation reproductive study conducted on atrazine was a pre-1998 guideline study, which would not include sensitive measures of endocrine disruption.

There was no evidence of increased sensitivity following exposure to atrazine in published peer reviewed studies performed by EPA's NHEERL laboratories. Specifically, exposure of lactating dams to atrazine during the days shortly after parturition results in an increased incidence and severity of prostate inflammation in nursing male offspring at doses which inhibited suckling-induced prolactin in exposed dams. Other studies by NHEERL show that exposure of developing male and female rats to atrazine delays the onset of puberty.

3.1.1 Chlorinated Metabolites

A limited toxicology database is available for the chlorinated metabolites of atrazine. The chlorinated metabolites appear to be of similar toxicity compared to the parent. In the prenatal developmental toxicity study in rats, there was no evidence (quantitative) for increased susceptibility following exposure to DACT. The maternal LOAEL was 25 mg/kg/day and the NOAEL was 2.5 mg/kg/day compared to the developmental LOAEL of 25 and the NOAEL of 2.5 mg/kg/day. Developmental effects (delayed ossification of certain bones) were seen in the presence of maternal effects, inhibition of suckling-induced prolactin.

3.1.2 Hydroxyatrazine

A limited toxicology database for hydroxyatrazine compounds is available. For acute toxicity hydroxyatrazine appears to be less toxic than atrazine. The only effects seen in any of the submitted studies which may be attributable to a single dose were developmental alterations in the developmental rat study. The developmental alterations seen in this study were seen only at the high-dose, were few in number, and were deemed by HIARC to be not of toxicological significance. Thus, HIARC did not select an acute endpoint for hydroxyatrazine, and concludes that no toxicologically significant endpoint to represent a single exposure can be found in the toxicology database for hydroxyatrazine. For chronic toxicity, the NOAEL selected for risk assessment by HIARC was 1.0 mg/kg/day, based on kidney alterations caused by the formation of hydroxyatrazine crystals in the blood at the next highest dose, the LOAEL of 7.5 mg/kg/day. This endpoint, which is based on entirely different effects than the parent compound, is comparable to NOAEL of 1.8 mg/kg/day used for the atrazine chronic risk assessment. In a combined chronic/carcinogenicity study conducted with Sprague-Dawley (BR strain) rats, both male and female rats exhibited gross and histopathological effects in the kidneys after exposure to hydroxyatrazine. A chronic RfD of 0.01 mg/kg/day was derived from this endpoint for chronic dietary risk assessment.

3.2 Food Quality Protection Act (FQPA) Considerations

3.2.1 Atrazine and the Chlorinated Metabolites

Taking into account the HIARC recommendation regarding residual concerns for uncertainties associated with Atrazine's neuroendocrine mode of action, the FQPA Safety Factor Committee (SFC) recommended that the default 10X Special FQPA Safety Factor is necessary to protect the safety of infants and children in assessing dietary (food + drinking water) exposures; and that an additional 3X Special FQPA Safety Factor is adequate to protect the safety of infants and children in assessing residential exposure and risks.

The Committee concluded that, as to dietary risk, the default 10X FQPA safety factor is statutorily required because of the absence of reliable evidence showing that an additional safety factor different than the statutory 10X default would be protective of infants and children. The principal grounds for this conclusion are:

(1) the HIARC identified residual concerns for the effects of the neuroendocrine mode of action described for Atrazine on the development of the young (Refer to Section I.3.B.). These concerns could not be accounted for in the determination of toxicity endpoints and traditional uncertainty factors to be used in risk assessment; and,

(2) residual concerns were also identified with regard to the drinking water exposure assessment. The various water monitoring data sources which exist for Atrazine and its chlorinated metabolites indicate that exposure via drinking water sources is high in some of the systems that have been monitored and widespread low levels are commonly detected. Although it is known that there is significant, widespread exposure to Atrazine and its metabolites in drinking water, limitations in the extent, frequency, and compounds tested for in the monitoring data raise significant uncertainties regarding the level of exposure to Atrazine and its metabolites.

Because of these uncertainties, the Committee concluded there is not reliable data to assign an additional safety factor that would adequately protect the safety of children by insuring that exposure in drinking water is not underestimated. The FQPA specifies that in the absence of such reliable data a default value of 10X is to be used as an additional safety factor for the protection of infants and children. As discussed below, the Committee believes there are reliable data to address the residual uncertainties regarding the neuroendocrine mode of action; however, because reliable data is not available as to all of the issues raising residual uncertainties, use of the default 10X factor is appropriate.

The Committee concluded that an additional Special FQPA safety factor of 3X is adequate for assessing residential exposures to Atrazine / DACT because the concerns for drinking water (described above) would have little or no impact on the residential exposure scenarios. The concerns for the effect of the neuroendocrine mode of action on the development of the young remain and the Committee concluded that there are reliable data to address these concerns through use of an additional Special FQPA Safety Factor of 3X (Refer to Section I.3.B for the rationale that this factor would be adequate to account for these hazard-based residual uncertainties).

The 10X FQPA safety factor is being applied across all aggregate risk assessments based on estimated dietary exposures for all populations considered in these risk assessments. The 3X FQPA safety factor is being applied across all aggregate risk assessments based on estimated residential exposures for all populations considered in these risk assessments. The FQPA safety factor has not been applied to any occupational risk assessments.

As per the Office of Pesticide Program's (OPP's) policy, a reference dose (RfD) modified by an FQPA safety factor is referred to as a population adjusted dose (PAD). As a FQPA safety factor was retained as 10X for dietary exposure, an acute PAD of 0.01 mg/kg/day, and a chronic PAD of 0.0018 mg/kg/day were used to estimate risk in the assessments based on acute and chronic aggregate exposures, inclusive of food and drinking water, respectively. For residential exposures a target MOE of 300 reflects an FQPA safety factor of 3X.

3.2.2 Hydroxyatrazine

The FQPA Safety Factor Committee following review of the hazard and exposure (food, water and residential) data recommended that the FQPA safety factor be removed (1x) when assessing the hydroxy-metabolites since:

- There was no evidence of increased susceptibility in the prenatal developmental toxicity study in rats with hydroxyatrazine;
- There is no evidence of neurotoxicity from the submitted toxicity studies;
- The neuroendocrine effects described for atrazine are postulated to be part of a cancer mode of action for atrazine in Sprague-Dawley rats. Because hydroxyatrazine is non-carcinogenic, the current belief is that the neuroendocrine effects described for atrazine are not occurring following hydroxyatrazine exposure;

- The dietary and non-dietary exposure assessments do not underestimate the potential exposures for infants and children; and

- The drinking water exposure concerns expressed for atrazine and the chlorinated metabolites do not apply to hydroxyatrazine, given its dissimilar toxicological profile and environmental fate properties that indicate that hydroxyatrazine is less mobile in soil/water systems.

As per the Office of Pesticide Program's (OPP's) policy, a reference dose (RfD) modified by an FQPA safety factor is referred to as a population adjusted dose (PAD). As a FQPA safety factor was reduced to 1X for hydroxyatrazine, the chronic RfD and chronic PAD are equal, and a chronic PAD of 0.01 mg/kg/day was used to estimate risk in the assessments based on chronic exposures to hydroxyatrazine through food, only.

3.3 Dose-Response Assessment

The toxicity endpoints selected for risk assessments conducted for atrazine and the chlorinated metabolites are presented in Table 2. The toxicity endpoints selected for risk assessment for hydroxyatrazine are presented in Table 3. Risk assessments included in this document are: an acute dietary assessment (combining a distributional analysis of one-day exposures to atrazine and the chlorinated metabolites in food with a screening-level assessment of high-end, one-day exposures to atrazine and the chlorinated metabolites in drinking water), a chronic dietary assessment (combining an assessment of average exposures to atrazine and the chlorinated metabolites in food with a screening-level assessment seasonal and average annual exposures to atrazine and the chlorinated metabolites in drinking water), a short-term assessment based on nonoccupational (residential) exposures of less than 30 days, and risk assessments for short- and intermediate-term occupational exposure scenarios.

3.3.1 Atrazine and the Chlorinated Metabolites

a. Acute Reference Dose (aRfD)

The acute RfD is used to assess acute dietary risk based on one-day oral exposures to atrazine and the chlorinated metabolites in the diet. An acute RfD of 0.10 mg/kg/day was derived from the NOAEL of 10 mg/kg/day and an uncertainty factor of 100 to account for interspecies variation and intraspecies extrapolation. The NOAEL of 10 mg/kg/day was based on delayed ossification seen at 70 mg/kg/day (LOAEL). This acute RfD is supported by other developmental studies (delayed puberty, and prolactin suppression induced prostatitis) consistent with atrazine's neuroendocrine mode of action.

The dose and endpoint was selected based on a weight of evidence approach using four studies; three of the four studies evaluated the developmental toxicity potential in two strains of rats (Charles River (CR) and Sprague Dawley) and the other was conducted with New Zealand White rabbits. The fourth, (a nonguideline study), examined the effects of maternal atrazine exposure during lactation on prostate effects in male suckling offspring. The recent pubertal assays in rats also support the acute RfD.

The high-level dose in the study using SD rats was 100 mg/kg/day, and mid-level dose in the study using CR rats was 70 mg/kg/day. The next lowest dose tested in study using the SD rat was 25 mg/kg/day; it was 10 mg/kg/day in the study using the CR rats. No observable adverse effects were seen at the 25 and 10 mg/kg/day dosing levels. Because skeletal anomalies such as delayed ossification of certain cranial bones (structures) were seen in each of the studies, respectively, at or above 70 mg/kg/day, and no observable adverse effects were seen at doses at or below 25 and 10 mg/kg/day, a developmental LOAEL of 70 mg/kg/day and NOAEL of 10 mg/kg/day were selected from these studies based on delayed ossification of cranial bones. The maternal LOAEL and NOAEL were 70 mg/kg/day and 10 mg/kg/day, respectively, based on reduced body weight gain.

The developmental study using rabbits gave very similar results and supports the selection of the LOAEL/NOAEL based on the rat studies. A somewhat wider dosing regime was used in the rabbit study with the high dose tested at 75 mg/kg/day and the next lowest dose tested at 5 mg/kg/day confirmed the results in the rat studies. No observable adverse maternal or fetal effects attributable to atrazine exposure were seen in the mid- (5 mg/kg/day) and low- (1 mg/kg/day) dose groups tested; however, the high-dose group showed evidence of reduced body weight gain in the dams, and delayed ossification in the offspring.

An additional developmental effect was identified from a study taken from the open literature designed to test for hyperprolactinemia in rats. This is a condition that if it occurs prior to puberty in male rats may lead to lateral prostate inflammation in young adult male rats. A possible cause of this condition is a deficiency in milk-derived prolactin from a nursing mother. This effect is most critical the first week after birth in the rat. If the developing male offspring does not receive sufficient prolactin from the mother during the first week of its life, it may result in prostatitis in the adult. Maternal exposure to atrazine in the first week after birth was shown to inhibit the release of suckling-induced prolactin into the mother's milk, which reduces the amount of prolactin received by the suckling male rat, and ultimately leads to an increase in the incidence of lateral prostate inflammation. This effect was seen in all nursing dams dosed twice daily at a 50 mg/kg/day, and for some but not others dosed twice daily at the 25 and 12.5 mg/kg/day. This effect was not observed in any of the dams dosed twice daily at the 6.25 mg/kg/day (12.5 mg/kg/day) dose.

Although the lowest NOAEL seen in the above studies was 5 mg/kg/day, which is the developmental NOAEL from the rabbit developmental toxicity study, and the NOAEL from this study would be acceptable for use as an acute RfD, HIARC noted that there was a large dose spread between the high and mid-doses tested in this study. The mid-dose tested (and the NOAEL) in this study was 5 mg/kg/day while the next highest dose tested (the highest dose tested and the LOAEL) was 75 mg/kg/day. This dose is a full 15 times higher than the mid-dose tested. The large spread between 5 and 75 mg/kg/day raises the possibility that had intermediate doses between 5 and 75 been used then the NOAEL would have been higher.

In further support of the NOAEL selected as the basis of the acute RfD, examination of the rat developmental toxicity studies indicates that intermediate doses in the rabbit study between 5 and 75 may not have shown any adverse effects. The NOAEL in both the rat studies are greater than 5 mg/kg/day, 10 mg/kg/day and 25 mg/kg/day, respectively. The effects seen in the rabbit and two rat developmental toxicity studies are similar with all three studies showing delayed or no ossification in certain cranial bones at their respective LOAELs of 75 mg/kg/day in the rabbit, 70 mg/kg/day in the rat, and 100 mg/kg/day in the rat. Other effects on which the developmental NOAEL were based in the rabbit study–reduced litter size and increased resorptions–were not seen either of the rat studies and are not considered to be frank malformations, or even variations. In this respect it should be noted that maternal effects were more severe at the LOAEL in the rabbit study than at the LOAELs in either of the two rat studies. The maternal LOAELs in the two rat studies were based on decreased food consumption and body weight, while the maternal LOAEL in the rabbit study was based on clinical signs such as none, little or soft stool, blood on the vulva, in addition to decreased food consumption and body weight. The HIARC also noted that this acute RfD derived from the NOAEL of 10 mg/kg/day would be protective of the prostatitis effects seen in the open literature study at a NOAEL of 12.5 mg/kg/day.

The weight-of-the-evidence for developmental effects taken from the four studies described above form the basis of the selection of the endpoint for acute risk assessment. The developmental effects seen in the two rat and one rabbit developmental studies are assumed to have the potential to occur after a single dosing. The effects seen in the open literature prostatitis paper occur after only four days of dosing. Since the endpoints of concern, delayed ossification and prostatitis, were seen *in utero and postnatally as a result of lactation*, respectively, these endpoints are appropriate for the population subgroup females 13 to 50 years of age, only. An appropriate endpoint for the general population including infants and children was not available from the available oral toxicity studies including the developmental toxicity studies in rats and rabbits. Although there is exposure, the lack of hazard indicates that there is no potential risk from a single oral dietary exposure for the general population including infants and children.

b. Chronic Reference Dose (cRfD)

The chronic RfD is used to assess chronic dietary risk based on oral exposures of six months to lifetime to residues of atrazine and the chlorinated metabolites in the diet (food and drinking water). A chronic RfD of 0.018 mg/kg/day was derived from the NOAEL of 1.8 mg/kg/day and an uncertainty factor of 100 to account for interspecies variation and intraspecies extrapolation. The NOAEL was based on attenuation of LH surge at 3.65 mg/kg/day (LOAEL).

The toxicity database available for the selection of this endpoint for chronic risk assessment was complete and of high quality. Estrus cycle alterations and luteinizing hormone (LH) surge attenuation levels in female Sprague-Dawley rats form the basis of the chronic toxicity endpoint selected for chronic dietary exposures. In a special nonguideline study designed to evaluate the effect of long-term atrazine exposure on the proestrus afternoon luteinizing hormone (LH) surge atrazine was administered to 360 female Sprague Dawley rats in the diet at the following dose levels: 0, 1.8, 3.65, or 29.44 mg/kg/day for approximately six months. This dose spacing was considered moderately steep.

Body weight, body weight gain and food consumption were significantly ($p \leq 0.05$) decreased in animals receiving the highest dose compared to controls. Body weights decreased by 8.5 percent at the end of the study and food consumption decreased 3.75 percent for the entire study. The percentage of days in estrus were significantly increased ($p \leq 0.01$) during the 21 to 22 and 25 to 26 week time periods at the highest dose tested. The percentage of days in estrus were also increased during the 21 to 22 and 25 to 26 week time periods at the mid dose tested, but the increase was only significant ($p \leq 0.05$) for the 21 to 22 week time period. The proestrus afternoon LH surge was severely attenuated at the high dose where LH levels at most sampling time points were actually decreased compared to baseline. LH levels were attenuated at the mid dose, but less so, where the maximum increase in LH levels above baseline was 157 percent compared to a maximum increase over baseline in controls of 273 percent. Pituitary gland weights were increased at the high dose (absolute weight increased 22 percent and weight relative to body weight was increased 28 percent). Pituitary gland weights at the other two doses were not affected. There was a slight increase at the high dose of animals displaying enlarged pituitaries (0 percent in controls compared to 3.4 percent at 29.44 mg/kg/day) and thickened mammary glands (0 percent in controls compared to 6.7 percent at 29.44 mg/kg/day). There were no other gross necropsy findings in the animals receiving the high dose that could be attributed to compound exposure, and there were no compound-related gross pathology findings at either the mid dose or low dose. Selected tissues were saved for histopathology but those results have yet to be reported. There were no compound related effects on mortality or clinical signs. The proestrus afternoon prolactin surge was not affected by compound exposure at any dose. The lowest dose tested of 1.8 mg/kg/day had no effects on the estrus cycle, LH or prolactin surges.

The attenuation of the LH surge is deemed to be a critical event in the mode of action of atrazine-associated carcinogenesis in the Sprague-Dawley strain of rat. This six-month study is considered adequate for use in selecting a chronic endpoint without an additional safety factor being added to account for study duration of less than 12 months. A LH surge study of longer duration may be of limited value given that the attenuation of LH surge occurs in normally aging Sprague-Dawley rats around nine months of age. Though this endpoint (LH surge attenuation and estrus cycle disruption) is applicable only to females 13-50, HED's HIARC noted that this dose is the lowest NOAEL available in the toxicology database (i.e., the most sensitive endpoint), and therefore would be protective of other adverse effects, including those occurring in males, infants and children. Further, the attenuation of the LH surge is considered a biomarker indicative of atrazine's ability to alter hypothalamic-pituitary function in general. Therefore, a separate endpoint was not selected for other populations (i.e., males, infants and children).

This dose and endpoint replaces the previous dose and endpoint of 3.5 mg/kg/day based on decreased body weight gain and food consumption in a two-year rat bioassay selected by HIARC in 1998. The dose of 1.8 mg/kg/day for use in risk assessment would be protective of effects that occur at the higher dose of 3.5 mg/kg/day as well as protective of effects such as LH surge attenuation and estrus cycle alterations, and any effects that may be associated with alteration of these parameters.

This endpoint is particularly appropriate for assessing intermediate-term and chronic exposures to atrazine in drinking water, as these exposures occur both as seasonal pulses from weeks to months in duration, and chronically from months to years in duration, reflective of atrazine's use patterns and occurrence in drinking water.

c. Short-Term (one to 30 days) Oral Exposures

For assessing the short-term (one to 30 days) risks from incidental oral exposures of toddlers, the HIARC selected the developmental NOAEL of 6.25 mg/kg/day based on delayed puberty in male rats as the endpoint. This effect was seen in male rat offspring dosed for 30 days at 12.5 mg/kg/day in a NHEERL study. This dose and endpoint, is appropriate for toddlers, who are the relevant population subgroup of interest under this exposure scenario and risk assessment.

d. Intermediate-Term (30 days to six months) Oral Exposures

For assessing the intermediate-term (30 days to six months) risks from incidental oral exposures of toddlers, the HIARC selected the NOAEL of 1.8 mg/kg/day based on attenuation of the LH surge used as a biomarker for alterations of hypothalamic-pituitary function from a sub chronic toxicity study in rats. This dose and endpoint, indicative of atrazine's ability to alter hypothalamic-pituitary function, in general, is appropriate for toddlers, the relevant population subgroup of interest under this exposure scenario and risk assessment.

e. Dermal Absorption

Dermal absorption studies are available both in rats and human and therefore a dermal penetration factor has been calculated. The available data indicates that skin permeability of atrazine is lower in humans than in rats. It is not uncommon for humans to have lower skin permeability to many compounds compared to rats. The stratum corneum known to absorb many compounds and serve as a reservoir of absorbed compound from which a compound steadily diffuses across the epithelium into the dermis is much thicker in rats than in the human resulting in this reservoir being a much greater factor to the rat than to the human. As a result rat dermal absorption frequently is much greater than human dermal absorption.

In the dermal absorption study with rats, dermal absorption was determined to be 22 percent based on absorption of the 0.1 mg/kg/day single dose left on the skin for 10 hours prior to wash-off, and then allowed to continue to adsorb for 82 hours prior to sacrifice. This value is selected because it represents the highest dermal absorption value seen following a 10 hour exposure (approximating a typical human workday) in the rat study. The majority of the dose applied to the skin was recovered in washes (65 to 95 percent) depending on the length of time the dose was left on the skin prior to wash-off.

In the dermal absorption study with humans, dermal absorption was estimated to be six percent based on the highest percent absorbed in this study. The majority of the dose (91 to 95 percent) was not absorbed. Skin was not washed for 168 hours. After 168 hours, a maximum of 5.6 percent of the dose was absorbed and excreted in the feces and urine of the low-dose group, and only 1.2 percent from the high-dose group. This dermal absorption factor (5.6 percent) has been applied to the dermal risk assessments when a dermal dose is selected from an oral study. A dermal absorption factor is used for route-to-route extrapolations.

f. Short-Term (one to 30 Days) Dermal Exposure

For short-term dermal exposure risk assessments, the HIARC selected the short-term effect of delayed puberty based on a NOAEL of 6.25 mg/kg/day established in a pubertal assay in rats. In a NHEERL study, this effect was seen in male rat offspring dosed at 12.5 mg/kg/day for 30 days. As stated earlier, since the dose is from an oral toxicity study, six percent dermal absorption from a human study is used to yield a dermal absorbed dose of 104 mg/kg/day (6.25 mg/kg/day ÷ 0.06 = 104 mg/kg/day) for risk assessments.

g. Intermediate-Term (30 days to six months) and Long-Term (six months to lifetime) Dermal Exposure

For incorporating intermediate- and long-term dermal exposure into risk assessments, the HIARC determined that the 21-day dermal toxicity study is not appropriate since the principal toxicological effect of concern (i.e., attenuation of LH surge) was not measured in the species tested (rabbits). Instead, HIARC determined that the effects observed in the subchronic study in the rat should be the basis of the endpoint, because both the principal toxicological effect of concern measured (i.e., attenuation of LH surge), and the exposure duration are appropriate for intermediate-term risk assessments. Therefore, the oral NOAEL of 1.8 mg/kg/day based on the attenuation of LH surge was selected for these risk assessments. Since an oral NOAEL was selected, thesix percent dermal absorption factor has been used in route-to-route extrapolation.

h. Inhalation Exposure

With the exception of an acute inhalation study, no inhalation studies are available for evaluation. Therefore the HIARC selected oral NOAELs for short, intermediate and long-term inhalation exposure risk assessments. For short-term inhalation exposure, the dose and endpoint of concern is the NOAEL of 6.25 mg/kg/day based on delayed puberty, and for intermediate-term exposure and long-term (chronic) exposure, the dose and endpoint of concern is the NOAEL of 1.8 mg/kg/day based on attenuation of LH surge as a biomarker indicative of atrazine's ability to alter hypothalamic-pituitary function, in general. A 100 percent inhalation absorption will be used for route-to-route extrapolations.

i. Aggregate Exposure

For risk assessments aggregating short-term exposures, the oral, dermal, and inhalation exposures can be combined since the endpoint (delayed preputial separation resulting in delayed puberty) is common via these routes. For intermediate-term and long-term (chronic) risk assessments, the oral, dermal, and inhalation exposures can be combined because they are based on oral equivalents from the same toxic effect (attenuation of LH surge as a biomarker indicative of atrazine's ability to alter hypothalamic-pituitary function in general).

j. Cancer Classification

In accordance with the 1999 Draft Guidelines for Carcinogen Risk Assessment, the CARC classified atrazine as "not likely to be carcinogenic to humans." The attenuation of the LH surge and estrus cycle disruptions appears to be a species, strain and sex specific effect occurring only in female Sprague-Dawley rats. The Agency's FIFRA Scientific Advisory Panel (SAP) convened in June 2000 determined that it is unlikely that atrazine's cancer mode of action in the SD rat is operative in humans. HED's Cancer Assessment Review Committee (CARC) also concluded that the mode of action is not relevant to humans. Although hypothalamic disruption of pituitary function (i.e., attenuation of the LH surge) and resulting estrus cycle disruption may be occurring in humans following atrazine exposure, the hormonal environmental resulting from these events would be expected to be much different from the environment seen in the rat. The prolonged/increased exposure to estrogen and prolactin seen in the rat would not be expected to occur in humans. Consequently, a cancer risk assessment was not conducted for atrazine. However, as stated above, the SAP also concluded that...."it is not unreasonable to expect that atrazine might cause adverse effects on hypothalamic-pituitary function in humans." Exactly what those effects in humans might be can only be deduced from the animal studies as previously described.

Table 2. Toxicology Endpoint Selection Table for Atrazine/DACT*

Exposure Scenario	Dose (Mg/kg/day)	Endpoint	Study
Acute Dietary (females 13 to 50 years of age)	NOAEL= 10 UF = 100 FQPA SF = 10	Delayed ossification of certain cranial bones in fetuses (LOAEL = 70 mg/kg/day). Decreased body weight gain in adult (LOAEL = 70 mg/kg/day).	Developmental toxicity study in rat & rabbit (weight of evidence from four studies)
	Acute RfD = 0.1 mg/kg/day **Acute PAD** = 0.01 mg/kg/day		
Chronic Dietary (all populations)	NOAEL = 1.8 UF = 100 FQPA SF = 10	Attenuation of preovulatory luteinizing hormone (LH) surge, as a biomarker indicative of hypothalamic function disruption (LOAEL = 3.65 mg/kg/day)	Six-month LH surge study -Rat
		Chronic RfD = 0.018 mg/kg/day **Chronic PAD** = 0.0018 mg/kg/day	
Oral, Short-Term (toddlers)	NOAEL= 6.25 UF = 100 FQPA SF = 3	Delayed preputial separation in male offspring after 30 days of dosing (LOAEL = 12.5 mg/kg/day)	Pubertal assay (30-day) NHEERL published literature
Oral, Intermediate-Term (toddlers)	NOAEL = 1.8 UF = 100 FQPA SF = 3	Attenuation of preovulatory luteinizing hormone (LH) surge, as a biomarker indicative of hypothalamic function disruption (LOAEL = 3.65 mg/kg/day)	Six-month LH surge- Rat
Dermal, Short-Term[a] (all populations)	NOAEL= 6.25 UF = 100 FQPA SF = 3	Delayed preputial separation in male offspring after 30 days of dosing (NOAEL + 6.25 mg/kg/day ÷ 0.06 = 104 mg/kg/day) (LOAEL = 12.5 mg/kg/day)	Pubertal assay (30-day) NHEERL published literature
Dermal, Intermediate- and Long-Term[b] (all populations)	NOAEL= 1.8 UF = 100 FQPA SF = 3	Attenuation of preovulatory luteinizing hormone (LH) surge, as a biomarker indicative of hypothalamic function disruption (LOAEL = 3.65 mg/kg/day)	Six-month LH surge- Rat
Inhalation, Short-Term [c] (all populations)	NOAEL= 6.25 UF = 100 FQPA SF = 3	Delayed preputial separation in male offspring after 30 days of dosing (LOAEL = 12.5 mg/kg/day)	Pubertal assay (30-day) NHEERL published literature

Table 2. Toxicology Endpoint Selection Table for Atrazine/DACT*

Exposure Scenario	Dose (Mg/kg/day)	Endpoint	Study
Inhalation, Intermediate and Long-Term [c] (all populations)	NOAEL= 1.8 UF = 100 FQPA SF = 3	Attenuation of preovulatory luteinizing hormone (LH) surge, as a biomarker indicative of hypothalamic function disruption (LOAEL = 3.65 mg/kg/day)	Six-month LH surge- Rat

Footnotes:

* DACT represents the chlorinated metabolites of atrazine. They are considered to have equivalent toxicity to atrazine.
[a]Use 6% dermal absorption factor for route-to-route extrapolation.
[b]Use 6% dermal absorption factor for route-to-route extrapolation.
[c]Use 100% inhalation absorption factor for route-to-route extrapolation.
MOE= Residential = A MOE of 300 is required and includes the 3X FQPA Safety Factor
Occupational = A MOE of 100 is adequate
PAD = Population Adjusted Dose

3.3.2 Hydroxyatrazine

Hydroxyatrazine is a metabolite of atrazine. Plants are capable of metabolizing atrazine to hydroxyatrazine. In plants it is the major metabolite. Bacteria are also able to metabolize atrazine to hydroxyatrazine. Animals do not metabolize atrazine to hydroxyatrazine. However, animals may receive hydroxyatrazine in their diets through forages and fodders.

Toxicity studies submitted under Subdivision F Guideline requirements (i.e., subchronic, chronic/carcinogenicity, and developmental) indicates that the kidney is the primary target organ for hydroxyatrazine associated toxicity. Hydroxyatrazine appears to crystallize in the serum leading to the formation in the blood stream of hydroxyatrazine crystals. These crystals cause direct physical damage to the kidney. This crystallization phenomenon has not been observed with atrazine or any of the chlorinated metabolites of atrazine. Hydroxyatrazine is not a chlorinated metabolite of atrazine, and is not expected to be associated with any of the effects attributed to atrazine or its chlorinated metabolites.

There is no evidence for increased susceptibility of rat fetuses following *in utero* exposure to hydroxyatrazine in the prenatal developmental toxicity study in rats. However, neither a prenatal developmental study in rabbits nor a two-generation reproductions study conducted with hydroxyatrazine in rats is available. In the prenatal developmental toxicity study in rats there was a statistically significant decrease in fetal weights and an increase in incompletely ossified interparietals and hyoid bones was seen in the presence of maternal toxicity. The developmental alterations seen in this study were seen only at the high dose, were few in number, and were deemed by HIARC to be not of toxicological significance. Thus, HIARC did not select an acute endpoint for hydroxyatrazine, and concluded that no toxicologically significant endpoint to represent a single exposure can be found in the toxicology database for hydroxyatrazine. While special studies and an open literature study indicate a neuroendocrine toxicity in the CNS of rats following atrazine exposure, overt signs of neurotoxicity were not seen in the toxicology studies for hydroxyatrazine. The neuroendocrine alterations mentioned above would not be expected to be seen following hydroxyatrazine exposure.

Hydroxyatrazine was non mutagenic with or without metabolic activation in revertant colonies of four *Salmonella* strains exposed to hydroxyatrazine. The metabolite did not cause an increase in micronuclei in mice in the *in vivo* mouse micronucleus assay. No evidence of unscheduled DNA synthesis was found in primary hepatocyte cultures treated *in vitro* with hydroxyatrazine. Negative results were reported in human fibroblast cells treated with hydroxyatrazine

a. Food Quality Protection Act (FQPA) Considerations

The FQPA Safety Factor Committee following review of the hazard and exposure (food, water and residential) data recommended that the FQPA safety factor be removed (1x) when assessing the hydroxy-metabolites since:

- There was no evidence of increased susceptibility in the prenatal developmental toxicity study in rats with hydroxyatrazine;

- There is no evidence of neurotoxicity from the submitted toxicity studies;

- The neuroendocrine effects described for atrazine are postulated to be part of a cancer mode of action for atrazine. Because hydroxyatrazine is non-carcinogenic, the currently available data do not indicate that the neuroendocrine effects described for atrazine are occurring following hydroxyatrazine exposure;

- The dietary and non-dietary exposure assessments do not underestimate the potential exposures for infants and children; and

- The drinking water exposure concerns expressed for atrazine and the chlorinated metabolites do not apply to hydroxyatrazine, given its dissimilar toxicological profile and environmental fate properties that indicate that hydroxyatrazine is less mobile in soil/water systems.

b. Acute Reference Dose (aRfD)

A toxicological endpoint attributable to a single exposure (dose) was not identified in the available toxicology database to establish an acute RfD. The only effects seen in any of the studies which may be attributable to a single dose were the development alterations in the developmental rat study which were seen only at the high dose, were few in number, and were not deemed by HIARC to be of toxicological significance. No other study in the database was found to have effects which could be attributed to a single exposure. Thus, HIARC concludes that no toxicologically significant endpoint to represent a single exposure can be found in the toxicology database for hydroxyatrazine.

c. Chronic Reference Dose (cRfD)

The chronic RfD is used to assess chronic dietary risk based on long-term oral exposures to residues of atrazine's hydroxy-metabolites in the diet. A chronic RfD of 0.01 mg/kg/day was derived from the NOAEL of 1 mg/kg/day and an uncertainty factor of 100 to account for interspecies variation and intraspecies extrapolation. The NOAEL was based on histopathological lesions of the kidney at 7.75 mg/kg/day (LOAEL).

In a combined chronic/carcinogenicity study conducted with Sprague-Dawley (BR strain) rats, both male and female rats exhibited gross and histopathological effects in the kidneys. No treatment-related increases in incidences of tumors of any type was observed in the treated male or female animals in this study. In particular, there was no increase above control levels in the incidence of mammary gland tumors in either males or females. In addition, onset times for mammary gland tumors in female rats were not decreased in this study.

d. Dermal Absorption

A dermal absorption study is not available with hydroxyatrazine. Therefore, the HIARC recommended that the six percent dermal absorption factor from atrazine should be used for hydroxyatrazine.

e. Short-Term (one to 30 Days) Dermal and Inhalation Exposures

For short-term dermal exposure risk assessments, the HIARC selected the maternal NOAEL of 25 mg/kg/day based on decreased food consumption and renal effects in dams in the developmental toxicity study in dams. Since an oral NOAEL was selected, the six percent dermal absorption and 100 percent inhalation absorption factor was used in route-to-route extrapolation.

f. Intermediate-Term (30 Days to Several Months) Dermal and Inhalation Exposures

For intermediate- and long-term dermal exposure risk assessments, the HIARC selected the oral NOAEL of 6.3 mg/kg/day based on the renal lesions in the subchronic toxicity study in rats. Since an oral NOAEL was selected, the six percent dermal absorption and 100 percent inhalation absorption factor was used in route-to-route extrapolation.

g. Long-Term (several months to lifetime) Dermal and Inhalation Exposures

For long-term dermal exposure risk assessments, the HIARC selected the oral NOAEL of 1 mg/kg/day based on the renal lesions in the combined chronic toxicity/carcinogenicity toxicity study in rats. Since an oral NOAEL was selected, the six percent dermal absorption and 100 percent inhalation absorption factor was used in route-to-route extrapolation.

h. Aggregate Exposure

Although a risk assessment for exposure to atrazine's hydroxylated metabolites in food was conducted, risk assessments aggregating exposures to atrazine's hydroxylated metabolites in food, drinking water, and in residential settings have not been conducted. There is only limited data on hydroxyatrazine in water and exposure to the hydroxy-metabolites of atrazine relative to the chlorinated metabolites is not expected to be significant in drinking water. Exposure to hydroxyatrazine from applications of atrazine to turf in residential settings is not expected. Hydroxyatrazine is formed within plant tissues once the atrazine has been absorbed into plant tissues and metabolized, and is not expected to form on plant surfaces.

i. Cancer Classification

Hydroxyatrazine has not been classified as to its carcinogenic potential by the HED Cancer Peer Review committee. The HED Metabolism Committee concluded in a September 29, 1995 meeting that: "For atrazine, the residues of concern for cancer dietary risk are parent and chloro-metabolites." Hydroxyatrazine is not a chloro-metabolite of atrazine, and is not considered by the HED metabolism committee to possess carcinogenic potential. In a combined chronic/carcinogenicity study conducted with Sprague-Dawley (BR strain) rats, both male and female rats exhibited gross and histopathological effects in the kidneys after exposure to hydroxyatrazine. A chronic RfD of 0.01 mg/kg/day was derived from this endpoint for chronic dietary risk assessment. Treatment-related increased incidence of tumors of any type were not observed in the treated male and female animals used in this study. In particular, there was no increase above control levels in the incidence of mammary tumors in either males or females. In addition, onset times for mammary gland tumors in female rats were not decreased in this study.

Table 3. Toxicology Endpoint Selection for Hydroxyatrazine

Exposure Scenario	Dose (Mg/kg/day)	Endpoint	Study
Acute Dietary	None selected	An appropriate endpoint attributable to a single dose was not identified	None selected
	Acute RfD = Not Established		
Chronic Dietary	NOAEL=1.0 UF=100 FQPA SF=1	Histopathological lesions of the kidneys (LOAEL = 7.75 mg/kg/day)	Combined chronic toxicity/carcinogenicity - Rat
		Chronic RfD = 0.01 **Chronic PAD** = 0.01 mg/kg/day	
Dermal, Short-Term [a]	NOAEL=25 UF=100 FQPA SF=1	Decreased food consumption and renal effects in the dams (LOAEL = 125 mg/kg/day)	Developmental toxicity - Rat
Dermal, Intermediate-Term[a]	NOAEL=6.3 UF=100 FQPA SF=1	Histopathological lesions of the kidneys (LOAEL = 22.75 mg/kg/day)	90-day study-Rat
Dermal, Long-Term[a]	NOAEL=1.0 UF=100 FQPA SF=1	Histopathological lesions of the kidneys (LOAEL = 7.75 mg/kg/day)	Combined chronic toxicity/carcinogenicity - Rat
Inhalation, Short-Term[a]	NOAEL=25 UF=100 FQPA SF=1	Decreased food consumption and renal effects in the dams (LOAEL = 125 mg/kg/day)	Developmental toxicity - Rat
Inhalation, Intermediate-Term[b]	NOAEL=6.3 UF=100 FQPA SF=1	Histopathological lesions of the kidneys (LOAEL = 22.75 mg/kg/day)	90-day study -Rat
Inhalation, Long-Term[b]	NOAEL= 1.0 UF=100 FQPA SF=1	Histopathological lesions of the kidneys (LOAEL = 7.75 mg/kg/day)	Combined chronic toxicity/carcinogenicity -Rat

Footnotes:

[a] se 6% dermal absorption factor for route-to-route extrapolation.
[b]Use 100% dermal absorption factor for route-to-route extrapolation.

MOE= 100 for Occupational; no potential exposure under residential settings.

3.4 Endocrine Disruption

There is direct evidence that atrazine is associated with endocrine disruption. Direct measurements of norepinephrine, dopamine, and GnRH, and of serum hormones such as certain steroid hormones and luteinizing hormone, as well as changes in estrus cycling and histomorphic changes in hormone responsive tissues, indicate neuroendocrine disruption.

The Agency is required under the FFDCA, as amended by FQPA, to develop a screening program to determine whether certain substances (including all pesticide active and other ingredients) "may have an effect in humans that is similar to an effect produced by a naturally occurring estrogen, or other such endocrine effects as the Administrator may designate." Following the recommendations of its Endocrine Disruptor Screening and Testing Advisory Committee (EDSTAC), EPA determined that there was scientific bases for including, as part of the program, the androgen and thyroid hormone systems, in addition to the estrogen hormone system. EPA also adopted EDSTAC's recommendation that the Program include evaluations of potential effects in wildlife. For pesticide chemicals, EPA will use FIFRA and, to the extent that effects in wildlife may help determine whether a substance may have an effect in humans, FFDCA authority to require the wildlife evaluations. As the science develops and resources allow, screening of additional hormone systems may be added to the Endocrine Disruptor Screening Program (EDSP).

Several assays which are classified as "Tier I Screens" under proposed EDSTAC guidelines (U.S. EPA Endocrine Disruptor Screening Program. 63 FR 42855; August 11, 1998. http://www.epa.gov/fedrgstr/EPA-PEST/1998/August/Day-11/) have already been performed on atrazine. These assays are described in the attached Toxicology RED chapter were primarily negative in regards to atrazine's ability to bind directly to the estrogen receptor. Other studies have also either been submitted by the Registrant, or published by EPA's NHEERL group. Unlike the "Tier I Screens" mentioned above, these studies did demonstrate an ability of atrazine to disrupt neuroendocrine activities (evidence of neurotransmitter and neuropeptide, and hormonal alterations were seen following atrazine exposure).

It should be noted that all these studies were *in vivo* studies which employed either the SD, Wistar or Long-Evans strain of rat. Registrant-submitted studies examining hormonal alterations in the F-344 rat are also available and were negative for endocrine-disrupting activity. When the appropriate screening and/or testing protocols being considered under the Agency's EDSP have been developed, atrazine may be subjected to additional screening and/or testing to better characterize effects related to neuroendocrine disruption.

4.0 EXPOSURE ASSESSMENT

4.1 Summary of Registered Uses

Atrazine (2-chloro-4-ethylamino-6-isopropylamino-*s*-triazine) is a triazine herbicide registered in the United States by Syngenta under the trade names Aatrex® and Bicep® for the control of annual broadleaf weeds in corn (field and sweet), guavas, macadamia nuts, sorghum, sugarcane, range grasses, and wheat (where application is to wheat stubble on fallow land following wheat harvests; wheat is not the target crop). Although not currently supported by the primary producer, tolerances for orchard grass and hay exist. HED recommends that these tolerances for orchard grass and hay be revoked. Atrazine is also registered for use on commercial (golf courses) and residential lawns for the control of broadleaf weeds in southern turf grasses. Because of the specific nature of the lawn uses, much of atrazine's use on lawns is confined to Florida and the Southeast.

Atrazine formulations registered to Syngenta for use on food/feed crops include flowable concentrate (FlC) and water dispersable granular (dry flowable, DF) formulations. These products may be applied as a broadcast or banded preemergence, preplant, or early postemergence application using either ground or aerial equipment. Most of the currently registered formulations are formulated as flowable concentrates ranging from 1.67 lbs/gallon to 4 lbs/gallon as shown in Table 4.

Table 4. End-Use Products with Food/Feed Uses Registered to Syngenta

EPA Reg No.	Label Acceptance Date	Formulation Class	Product Name
100-497 [a]	8/98	4 lb/gal FIC	Atrex® 4L Herbicide
100-585 [b]	8/98	90% DF	Atrex Nine-0® Herbicide
100-817[c]	4/99	3.1 lb/gal FIC	Bicep II MAGNUM® Herbicide
100-827[d]	5/99	2.67 lb/gal FIC	Bicep Lite II MAGNUM® Herbicide
100-886[e]	2/98	3.1 lb/gal FIC	Bicep MAGNUM® Herbicide
100-928[f]	11/98	2.0 lb/gal FIC	Bicep MAGNUM TR® Herbicide

Footnotes:

[a]Includes: SLN Nos. FL 80002400; IA970001; KS980003; MN0000040; OK830003; OK930004; OK830029; OK910003; OK920007; and TX920005.

[b]Includes: SLN Nos. ID830009; OK830003; OK910001; OK920008; OK910001; OK930005; OR790077; OR8000100; TX920006; VT80008; WA790078; WA800083.

[c]A MAI that also includes: *S*-metolachlor (2.4 lb/gal FIC) in addition to 3.1lb/gal of atrazine.

[d]A MAI that also includes: *S*-metolachlor (3.33 lb/gal FIC) in addition to 2.67 lb/gal of atrazine.

[e]A MAI that also includes: CGA-77102 (2.4 lb/gal FIC) in addition to 3.1 lb/gal of atrazine.

[f]A MAI that also includes: *S*-metolachlor (2.5 lb/gal FIC) and flumetsulam (0.09 lb/gal FIC) in addition to 2.0 lb/gal of atrazine.

Although there are some postemergence uses, atrazine, in general, is primarily used in early spring preplant and preemergence soil applications. Corn is treated with atrazine preplant, preemergence and postemergence before the corn plant is 12 inches tall. About 70 percent of the corn crop is treated preplant or preemergence and about 30 percent is treated postemergence. Average seasonal treatment rates are 1 to 1.5 lbs ai/acre with a maximum treatment rate of 2.5 lbs ai/acre. Sorghum use is similar, with an average seasonal use rate of 1.2 lbs ai/acre, and a maximum use rate of 2.5 lbs ai/acre. About 75 percent of the use on sorghum is preemergence and 25 percent is postemergence. Atrazine is used both pre- and postemergent on sugarcane at an average of 4 lbs ai/acre/sugar crop, and a maximum of 10 lbs ai/acre/sugar crop. On wheat, atrazine can be applied to <u>fallow</u> fields up to 1 lb ai/acre/year in a wheat-fallow-wheat rotation. Atrazine is used on macadamia nuts at a maximum of 2 to 4 lbs ai/year as needed, and on guava at a maximum 8 lbs ai/acre/year.

Currently, there are four products with labeled uses on pasture land and rangeland on terrestrial feed items (forages and fodder) or for road side (right-of-way) uses. Valent Atrazine 90DF (59639-106), Riverside Atrazine 90 DF (9779-253) and Oxon Italia 5L (35915-5) are labeled for application to roadsides at 2 pints per acre, and allow application to Conservation Reserve Program (CRP) land in NE, OR, OK, and TX at 2.2 lbs product/acre. Drexel Atrazine 4L (19713-11) is labeled for roadside uses, only. Both of these use patterns include prohibitions against grazing or cutting for hay. However, HED does not support label restrictions against grazing or feeding, and cutting for hay and grazing is allowed during drought.

The *perennial rye grass* and *orchard grass and hay* uses are unsupported by the registrant.

4.2 Dietary Exposure and Risk Assessment

HED's dietary exposure assessment for atrazine includes anticipated exposures through food and drinking water.

4.2.1 Residue Profile

Adequate residue data are available to assess dietary exposure to atrazine. Anticipated residues (ARs) of atrazine and its chlorinated metabolites were estimated for comparison to the appropriate acute and chronic endpoints identified for atrazine. Anticipated residues of atrazine's four hydroxy-metabolites were estimated for comparison to the appropriate chronic endpoint identified for hydroxyatrazine.

Monitoring data are available for atrazine, the parent compound only, for many foods. The USDA's Pesticide Data Program (PDP), Food and Drug Administration (FDA), and Food Safety and Inspection Service (FSIS) have all monitored for atrazine. In general, these monitoring data suggest that exposure to the parent atrazine through the diet is small. Because the parent atrazine is not found in any appreciable quantities in the fruiting parts of plants in the metabolism studies, it is difficult to estimate the total chloro- or hydroxy-metabolites in fruits, nuts or grains based upon testing for parent atrazine, alone. Therefore, for dietary exposure assessments, residues of atrazine, its chloro-and hydroxy-metabolites were estimated mostly from field trial and metabolism study data where possible as these studies included analyses for the chloro- and hydroxy-metabolites, as well as the parent compound, in the main crops on which atrazine is used. Except for sugar cane, all human foods treated with atrazine are fruits, nuts or grains. Sugar cane is highly processed before it is consumed by humans.

a. Plant and Animal Metabolism

Plant and animal metabolism of atrazine is well understood. In general, atrazine is metabolized in plants through replacement of the chloro-atom with either a hydroxy group or by a glutathione conjugate. This leads to three families of metabolites: the chlorinated metabolites, the hydroxy-metabolites, and the glutathione metabolites. Within each family, three additional metabolites can arise by removal of either one or both of the N-alkyl moieties. Other metabolites can also arise within the glutathione family of metabolites by metabolic changes to the glutathione conjugate.

All of the major modes of metabolism described above have been identified in plants and can be summarized as replacement of the chloro-atom with a hydroxy-group (hydrolytic dehalogenation), glutathione conjugation, and removal of either one or both of the N-alkyl groups (dealkylation). All routes leave the central triazine ring intact, and, since these modes exist in competition, all three families of metabolites (chloro-, hydroxy-, and glutathione conjugates) can exist in combination with each of the N-dealkylated forms. Metabolism by hydrolytic-dehalogenation dominates for residues absorbed through the roots while metabolism by glutathione conjugation dominates for foliarly applied residues.

Atrazine's metabolism in animals is similar to plants. However it is dominated by removal of either one or both of the N-alkyl groups (dealkylation), and subsequent glutathione conjugation. Hydroxy-metabolites of atrazine are not produced in tissues of animals dosed with atrazine, *per se*. As in plants, all metabolic routes in the animal leave the central triazine ring intact. The structures of atrazine and its chloro- and hydroxy-metabolites are given in Figure 2.

Figure 2. Atrazine and Major Plant and Animal Metabolites

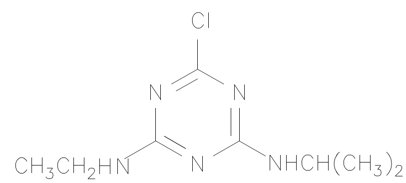
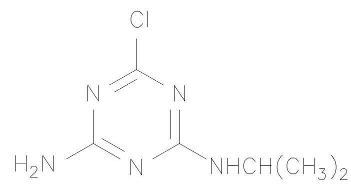
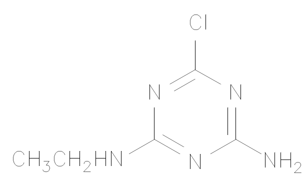
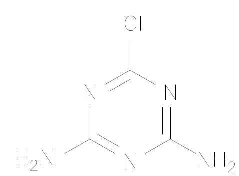
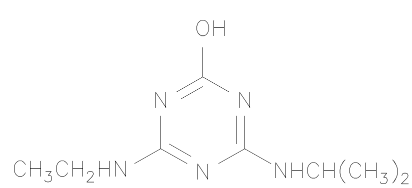
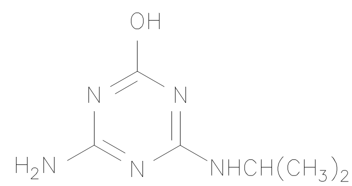
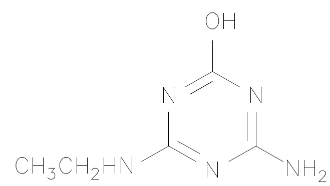
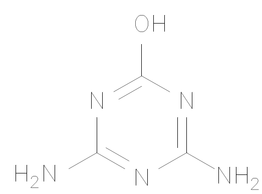
Common/Chemical Name (Code)	Chemical Structure
Atrazine 2-chloro-4-ethylamino-6-isopropylamino-*s*-triazine (G-30027)	
2-amino-4-chloro-6-isopropylamino-*s*-triazine (G-30033)	
2-amino-4-chloro-6-ethylamino-*s*-triazine (G-28279)	
2,4-diamino-6-chloro-*s*-triazine (G-28273)	
Hydroxyatrazine 2-hydroxy-4-ethylamino-6-isopropylamino-*s*-triazine (G-34048)	

Figure 2. Atrazine and Major Plant and Animal Metabolites

Common/Chemical Name (Code)	Chemical Structure
2-amino-4-hydroxy-6-isopropylamino-*s*-triazine (GS-17794)	
2-amino-4-hydroxy-6-ethylamino-*s*-triazine (GS-17792)	
Ammeline 2,4-Diamino-6-hydroxy-*s*-triazine (GS-17791)	

b. Tolerance Reassessment and Residues to be Regulated

Tolerances are established for residues of the herbicide atrazine, 2-chloro-4-ethylamino-6-isopropylamino-s-triazine, in or on agricultural plant and animal commodities (40 CFR 180.220(a)(1), and for combined residues of atrazine and its metabolites 2-amino-4-chloro-6-ethylamino-s-triazine (G-28279), 2-amino-4-chloro-6-isopropylamino-s-triazine (G-30033), and 2-chloro-4,6-diamino-s-triazine (G-28273), in or on specified plant commodities (40 CFR 180.220(a)(2). See Table 20 (Section 9.0).

As a result of tolerance reassessment, HED's Metabolism Assessment Review Committee (MARC) has determined that the residues to be regulated by established tolerances in plant and animal commodities are atrazine and its chlorinated metabolites: desethyl atrazine (G-30033), desisopropyl atrazine (G-28279), and diaminochlorotriazine (G-27283). The HED MARC has also determined that separate tolerances must be established for residues of the hydroxyatrazine metabolites: G-34048, GS-17794, GS-17792, and GS-17791 in plants. Analytical methods are available to analyze for each of these compounds in plants and animals.

In general, the tolerance reassessment process resulted in a lowering of tolerances for most raw agricultural plant commodities and a slight raising of tolerances for animal commodities. The lowered tolerances on the plant commodities reflect seasonal use rate reductions in corn from 4 lbs ai/acre to 2.5 lbs ai/acre. The rise in tolerances for animal commodities reflects the HED MARC decision to include the chlorinated metabolites of atrazine in animal tolerances. Reassessed tolerances for atrazine can be found in HED's Product and Residue Chemistry Chapter for Atrazine (Attachment IV).

HED's Chemistry Science Assessment Committee determined that because there was no reasonable expectation of finite residues of atrazine, its chloro- and hydroxy-metabolites in tissues of hogs, or in poultry tissues and eggs, these commodities could be classified as 180.6(a)3, "no reasonable expectation of finite residues" (HED memoranda D269608 & D269514, C. Eiden, 10/15/00 & 10/05/00). HED recommends that the existing tolerances on *hogs, fat, hogs, meat, hogs, mbyp,* and *poultry fat, poultry meat, poultry mbyp*, and *eggs* under the 40 CFR 180.220(a)(1) be revoked. As the primary producer of atrazine is no longer supporting uses of atrazine on orchard grasses and orchard grass, hay, HED recommends that the established tolerances for residues in/on *orchard grass and orchard grass, hay* under the 40 CFR 180.220(a)(2) be revoked. HED recommends that existing tolerances be revoked for *sugarcane fodder and forage* under the 40 CFR 180.220(a)(1) because these are not significant livestock feed items. The commodities with tolerances recommended for revocation above have not been included in the dietary exposure assessments, as either animal feeds or human foods.

The HED MARC has determined that the concentrations of atrazine and the chlorotriazine metabolites of concern for acute dietary risk are the parent and chlorinated metabolites (memoranda: C. Eiden, 10/05/00, D269513 & C. Eiden, 11/15/00). The HED MARC has also determined that the residues of concern for chronic noncancer dietary risk are: (i) combined free hydroxy-metabolites; and (ii) parent and chlorinated metabolites. Separate chronic reference doses (RfDs) have been identified for each of these sets of residues for the purposes of chronic dietary exposure assessment. The group of metabolites that retain the chloro-atom, including parent and the three metabolites formed by loss of either or both N-alkyl groups from the parent are assumed to have the same toxicological effects as atrazine. Therefore, the dietary exposure and risk assessment has been conducted for the combined residues of atrazine and the chlorinated metabolites. Since, the HIARC has assigned a separate toxicological endpoint to hydroxyatrazine for risk assessment, a risk assessment for food exposures, only, has been conducted for the combined residues of atrazine's four hydroxy-metabolites. The group of four hydroxy-metabolites is formed by replacement of the chloro-atom with a hydroxy-group plus loss of either or both N-alkyl groups. All four compounds are assumed to have same toxicological effect and their combined residues have been compared to the endpoint specific to hydroxyatrazine in a separate risk assessment.

Although there are tolerances for range grasses, residues on range grasses were not included in the dietary assessment for meat and milk, as these uses are limited to 3.5 million acres under the Conservation Reserve Program (CRP) in OK, OR, NE, and TX. The CRP is administered by the USDA. Atrazine is applied to these lands to clear away existing grasses and allow the selected native grass to become established. As a result, applications of atrazine occur prior to planting the native grasses. Under this use, it is prohibited to use these lands for grazing and to cut the grasses for hay, except in national emergencies. Concentrations of atrazine and the chlorotriazine metabolites are expected to be insignificant by the time any native grass would be harvested for feed as in the case of a national emergency. Further, atrazine is used on at least 70 percent of the U.S. corn crop, which is estimated at 70 million acres annually. Since corn grain and forage are significant livestock feed items and are fed preferentially to beef cattle for fattening before slaughter, it is expected that concentrations of atrazine and the chlorotriazine metabolites in corn forage and grain impact the livestock diet to a greater degree than range grasses grown on CRP lands. Because of the limited acreage, timing of application, restrictions on the use of these range grasses for animal feeds, and the dominance of corn as a feed item, range grasses are not expected to impact either the livestock diet or the risk estimates significantly, and consequently were not included in the dietary exposure assessments.

c. Anticipated Residues Used to Estimate Dietary Exposure

Anticipated residues were derived in accordance with established Agency policies and guidance for chronic and acute dietary exposure assessments. Residues for chronic dietary exposure analyses are generally based on the mean of the best available residue data with appropriate adjustments for percent crop treated and residue concentration/reduction from processing. Acute anticipated residues were derived using guidance provided in HED SOP 99.6 (Classification of Food Forms with Respect to Level of Blending (8/20/99)). Anticipated residues in milk for use in acute and chronic dietary exposure assessments were determined in accordance with HED memorandum “Clarification of AR Calculation for Meat/Milk in Acute Assessments,” 10/14/99, D. Miller. Each food form included in the dietary exposure assessments is classified as being blended (B), partially blended (PB), or not blended (NB). The only food form included in the dietary risk assessments for atrazine as a nonblended form was guavas. However, since no residue data were available on guavas from either field trials or monitoring data, and tolerance level residues were entered into the dietary assessments, there was no need to decomposite monitoring data that may have been collected on composite samples of foods. The only monitoring data used in dietary assessments for atrazine were for wheat, which is a blended commodity, and therefore, there was no need to decomposite these monitoring data. The exact anticipated residue values used in the dietary exposure assessments and supporting calculations for each commodity are provided in HED's "Anticipated Residues and Acute and Chronic Dietary Exposure Assessments for Atrazine" (Attachment V).

d. Residue Data for Raw Agricultural Commodities

The USDA’s Pesticide Data Program (PDP) monitored for atrazine, *per se*, in 1993 through 1997 in a wide variety of foods including peaches, pears, apples, bananas, grapes, oranges, apple juice, spinach, wheat, green beans, potatoes, sweet corn, tomatoes, lettuce, and milk. Analytical method sensitivities ranged from 0.001 ppm to 0.03 ppm. In the PDP data, there were 27 positive findings of atrazine in wheat out several hundred wheat samples tested each year, and four findings for atrazine in spinach out of a several hundred spinach samples tested. All positive findings in spinach came from New York. These are violative samples as no tolerances for spinach have been established. Most results were at the limit of quantification, but a few results in wheat did range up to 0.03 ppm. All other RACs tested had nondetectable residues for atrazine. PDP did not test samples of sugar cane, field corn, sorghum, guava or macadamia nuts for atrazine.

The FDA monitored for atrazine, parent only, in a wide variety of foods between 1993 through 1998. FDA had six positive findings for atrazine in romaine/iceberg lettuce and endive in 1997. All were from Florida. Results were mostly at the limit of quantification, but did range up to 0.045 ppm atrazine in lettuce. These are violative samples as no tolerances for these commodities have been established. FDA analyzed several hundred samples of each leafy vegetable commodity (romaine, iceberg, endive) each year during this sampling period. These residues may have resulted from rotational crops planted to corn fields after atrazine use. Current plant back intervals are set at 12 months. As quantifiable chlorotriazine residues were detected in soybean forage collected from the 12-month PBI (NY test) limited field trials have been required, as described under OPPTS GLN 860.1900, to determine appropriate tolerances for inadvertent residues of atrazine in the foliage of legume vegetables. (See Attachment IV.)

FSIS monitored for parent atrazine in the fat of the predominant species of meat animals in 1989 through 1990. FSIS reported finding no detectable residues of atrazine in fat above the currently established tolerance set at 0.02 ppm. Although a method with a sensitivity of 0.005 ppm was used, FSIS only reported finding no samples above the tolerance; but did not report whether there were any positive findings below the tolerances.

Extensive field trials, including recently updated trials reflecting currently labeled use rates, exist for atrazine on corn and sorghum, and adequate field trials also exist on sugar cane and wheat. In these field trials, samples were analyzed for residues of atrazine, each of the three chlorinated metabolites, and each of the four hydroxy-metabolites of atrazine. Old, limited field trials exist for macadamia nuts and guava, in which samples were analyzed for atrazine, *per se*, only. The guava tolerance is translated from use on other crops. Processing studies are available for processing of sugar cane into refined sugar and molasses. Residue data from the October 18, 1988 Registration Standard Document show residues concentrating in molasses up to 6X and <1X in refined sugar. Because concentrations of atrazine and the chlorotriazine metabolites were nondetectable on the sugarcane from this study treated at a 2X rate, a new processing study has been required. A tolerance for sugarcane molasses will be determined from the results of this study. Processing studies are also available for corn, sorghum, and wheat indicating that residues do not concentrate in edible portions of corn, sorghum, and wheat commodities.

Adequate metabolism studies were available for corn, sorghum and sugar cane. Samples from the corn, sorghum and sugarcane studies were analyzed for residues of atrazine, each of the three chlorinated metabolites, and each of the four hydroxy-metabolites of atrazine. Metabolism studies were not available for wheat, guava or macadamia nuts.

Because no reliable field trial data or monitoring data or metabolism data existed for guava, concentrations of atrazine and the chlorotriazine metabolites (chloro- and hydroxy-metabolites) were estimated in the exposure assessment based on the established tolerance in guava. Estimates of dietary exposure to atrazine and its chloro- and hydroxy-metabolites based on these assumptions are expected to be conservative and result in overestimations of exposure from guava in the diet.

There were no monitoring data for macadamia nuts, but there were acceptable field trials. All samples from the field trials had nondetectable residues at a limit of detection (LOD) of 0.05 ppm for atrazine and each of the chlorinated metabolites. Residues of atrazine and its chlorinated metabolites in macadamia nuts were estimated in the exposure assessment as the sum of ½ of the LOD for each compound. No metabolism study data were available for macadamia nuts. Neither monitoring nor residue data from field trials were available for the hydroxy-metabolites of atrazine, so the existing tolerance for atrazine in macadamia nuts was used for the dietary assessment for the hydroxy-metabolites. Estimates of dietary exposure to atrazine and its chloro- and hydroxy-metabolites based on these data and assumptions are expected to be conservative and result in overestimations of exposure from macadamia nuts in the diet.

With the exception of a single finding at the LOD for a single hydroxy-metabolite in corn grain in a single field trial, all samples analyzed for atrazine, and its chloro- and hydroxy-metabolites in the corn grain from field trials had nondetectable residues in the edible portions of the crop. All monitoring data showed nondetectable residues of atrazine, but only sweet corn was monitored. Residues of atrazine in field corn have not been monitored by USDA's PDP, FDA or FSIS. Residues of atrazine, and its chloro- and hydroxy-metabolites were found in feed and forage portions of the corn in the field trials. In the exposure assessment, residues in corn grain were estimated from radioactive measurements in the metabolism studies for atrazine and the chlorinated metabolites since the greater sensitivity of these results offered considerable refinement over the field trials. Estimations of the hydroxy-metabolites in corn grain are based on field trials. Estimates of dietary exposure to atrazine, the chloro- and hydroxy-metabolites in edible forms of corn based on these data and assumptions are considered refined, but still conservative.

All field trials showed nondetectable residues of atrazine, and its chloro- and hydroxy-metabolites in sorghum grain. There were no monitoring data for sorghum. To improve refinement, residues for the exposure assessment were estimated from radioactive residues of atrazine, and its chloro- and hydroxy-metabolites detected in sorghum metabolism studies. Estimates of dietary exposure to atrazine, the chloro- and hydroxy-metabolites in edible forms of sorghum based on these data and assumptions are considered refined, but still conservative.

There were no monitoring data for sugar cane. A combination field trial/processing study existed, producing samples with nondetectable residues for atrazine and the chlorinated metabolites in cane sugar and cane molasses. Therefore, a summation of residues at ½ the LODs for atrazine and each chlorinated metabolites was used in the exposure assessment. For the hydroxy-metabolites of atrazine, a value was estimated from a direct measurement in sugar cane molasses from the processing study. No result for the hydroxy-metabolites in refined sugar was available, so a result was extrapolated from the molasses residue, which included information on reduction of residues in refined sugar processed from cane molasses. Estimates of dietary exposure to atrazine, the chloro- and hydroxy-metabolites in edible forms of sugar based on these data and assumptions are considered refined, but still conservative.

All field trial samples for wheat grain had nondetectable residues of atrazine. PDP did monitor wheat for atrazine, only. Atrazine was found in the monitoring data for wheat grain collected under PDP, and these monitoring data were used in the exposure assessment for wheat. Residues of the chlorinated metabolites in wheat grain were estimated using ratios of atrazine to the chlorinated metabolites from field trials with residue data on wheat forage. For the hydroxyatrazine assessment, the ratio of hydroxy-metabolite residues in wheat forage to parent atrazine in wheat forage was used to convert the residues of parent atrazine found in the PDP monitoring to hydroxy-metabolite residues. Estimates of dietary exposure to atrazine, the chloro- and hydroxy-metabolites in edible portions of wheat based on these data and assumptions are considered refined, but still conservative.

The specific details regarding the calculation and estimation of anticipated residues of atrazine, the chloro- and hydroxy-metabolites in edible portions of crops for use in dietary exposure assessment can be found in Attachment V.

e. Residue Data for Meat, Milk Poultry, and Eggs

Residues of atrazine and the chlorinated metabolites may occur in the meat and milk of ruminants as a result of residues present on livestock feeds. These residues could transfer to the human diet through the consumption of meat and milk. As mentioned above, HED's Chemistry Science Assessment Committee determined that residues of atrazine, its chloro- and hydroxy-metabolites were not be expected in tissues of hogs, or in poultry tissues and eggs and could be classified as 180.6(a)3 (memoranda dated 10/5/00 and 10/15/00, C. Eiden, D 269514 & D269608). This decision was based largely on the results of animal feeding studies, in which, residues of atrazine were nondetectable at theoretical dietary burdens. These animal commodities were not included in the dietary exposure assessments.

In 1997 and 1998, PDP tested 1892 samples of milk for atrazine (parent only). All samples had nondetectable residues of atrazine at an average LOD of 0.0075 ppm. Since all samples showed nondetectable residues, more refined estimates were calculated using mass balance estimates using residues found in feed crops and animal feeding studies. Anticipated residues for atrazine and the chlorinated metabolites in meat and milk of ruminants were based on the results of submitted, acceptable animal feeding studies, and reasonable theoretical dietary burdens for beef and dairy cattle. Although not detected in the grains of corn and sorghum, atrazine, the chlorinated metabolites, and the hydroxy-metabolites were detected in animal forages and fodders used for feed. Field trial data were used to calculate anticipated residues in feeds, which were used to estimate the reasonable theoretical dietary burdens for beef and dairy cattle. The reasonable theoretical dietary burdens were used to estimate anticipated residues of atrazine in meat and milk.

The anticipated residue for residues of atrazine and the chlorinated metabolites in milk for chronic dietary exposure assessment was based on residue values from an animal feeding study. Residues in milk at each day of sampling were summed, averaged, and extrapolated to residue values anticipated based on the reasonable theoretical dietary burden for dairy cattle. All samples with nondetectable residues (< 0.01 ppm) were included in the calculation as ½ of the LOD (0.005 ppm).

Anticipated residues for acute dietary assessment of atrazine and the chlorinated metabolites in milk, were based on summing all residues detected of atrazine and the chlorinated metabolites in milk samples taken on a specific day once a plateau in residue values was reached in the study, then averaging the daily values, and extrapolating to residue values anticipated based on the reasonable theoretical dietary burden for dairy cattle. All samples with nondetectable residues were included in the calculation as ½ the LOD (0.005 ppm).

The specific details regarding the calculation and estimation of anticipated residues of atrazine, the chloro- and hydroxy-metabolites in animal tissues and milk for use in dietary exposure assessment can be found in Attachment V.

f. Percent Crop Treated Information

HED used information on the percentage of crops treated with atrazine supplied by the registrant and contained in OPP's Biological Economic and Analysis Division's (BEAD) Quantitative Usage Analysis (QUA) dated January 2001. BEAD has recently updated percent crop treated information for atrazine. The estimates of usage are considered to be good, estimated with 0.1 percent precision for the major crops. The estimated percentages of crop treated used in the dietary assessment were: sugarcane, 76 percent (weighted average) to 95 percent (maximum); sweet corn, 50 percent (weighted average) to 60(maximum); other corn, 75 percent (weighted average) to 84 percent (maximum); sorghum, 59 percent (weighted average) to 74 percent (maximum); and, wheat, less than one percent. BEAD estimated use on macadamia nuts to be approximately 57 percent. Syngenta has suggested that no more than 10 percent of the guava crop is treated with atrazine, and BEAD has affirmed that this estimate should be conservative. This information on the percentage of the crop treated has been incorporated, as appropriate, into HED's estimates of reasonable theoretical dietary burdens for beef and dairy cattle, and anticipated residues in human foods.

g. Processing Factors

While some processing data is available for the sugar cane products, no other cooking or processing information was available for atrazine, and all other processing factors are DEEM™ default factors.

h. Confined Rotational Crops

An adequate confined rotational crop study demonstrated that metabolism in rotated crops proceeds via essentially the same pathway as that in primary crops.

Limited field rotational crop studies provided data on residues of atrazine and chloro-metabolites and two hydroxy-metabolites (G-34048 and G-17794) in representative rotational crops (leaf lettuce/spinach, potatoes, wheat, and soybean) planted five months (lettuce and wheat only) and 10 to 12 months following a single postemergence application of the atrazine (4 lb/gal FlC) at 3 lb ai/A/season (1.2X the current maximum seasonal rate and 1.5X the current maximum postemergence rate) to a primary corn crop.

Chlorotriazine residues were nonquantifiable in/on representative rotational crop commodities with few exceptions. Residues of G-28273 were 0.10 ppm in one treated lettuce sample from the five-month plant-back interval (PBI). In one wheat trial (five-month PBI; CA) residues of atrazine were 0.06 ppm, and G-30033 residues were 0.06-0.09 ppm in/on two treated fall forage samples; G-28273 residues were 0.06 ppm in/on two treated straw samples. [Although data were not available on wheat from later PBIs, the [^{14}C]atrazine confined study indicated that total chlorotriazine residues may be expected to decline to levels below the method LOQs for wheat forage, grain, and straw at the nine-month PBI.] In addition, two treated soybean forage samples collected from the 11 to 12 month PBI bore residues of G-28279 and G-30033 at 0.11-0.12 and 0.08-0.09 ppm, respectively.

Residues of both hydroxy-metabolites were <0.02 ppm (<LOQ) in/on treated samples of rotational crops, with the exception of two treated samples of straw (CA test; five-month PBI) and soybean forage (NY test; 12-month PBI) that each contained residues of GS-17794 at 0.03 ppm.

As the current atrazine EP labels specify a rotational crop restriction of 12 months for rotational crops other than sorghum and corn, tolerances for residues of atrazine in certain rotational crops (small grains, leafy vegetables, and root crops) will not be required. However, as quantifiable chlorotriazine residues were detected in soybean forage collected from the 12-month PBI (NY test) limited field trials are required, as described under OPPTS GLN 860.1900, to determine appropriate tolerances for inadvertent residues of atrazine in the foliage of legume vegetables.

i. Dietary Risk Estimates

These exposure assessments were performed using the Dietary Exposure Evaluation Model (DEEM^{TM}). DEEM^{TM} software was developed by Novigen Sciences, Inc. to perform dietary exposure analyses. DEEM^{TM} software enables the user to match residues found in various foods to the consumption of those foods by the U.S. population and by various subgroups of that population. The food consumption for these populations is taken from USDA's Continuing Survey of Food Intake by Individuals (CSFII), 1989-92 report. When residue data are input into DEEM^{TM}, estimated exposures are reported out both in terms of the absolute exposure (mg/kg/day) and exposure relative to the toxicological endpoint, i.e., as a percentage of the RfD or the population adjusted dose (PAD). Further information on dietary exposure assessment as it is performed by EPA is available at the EPA web site at: http://www.epa.gov/fedrgstr/EPA-PEST/2000/July/Day-12/6061.pdf . Further information on the DEEM^{TM} program is available at: http://www.epa.gov/scipoly/sap/2000/February/

4.2.2 Acute Dietary Risk Estimate

As previously summarized, acute dietary exposure assessments were conducted for atrazine and its chlorinated metabolites in a refined assessment using anticipated residues based on monitoring data, field trials, metabolism studies, one tolerance level residue for guava, and probabilistic techniques of analysis. As per OPP policy, a reference dose (RfD) modified by a FQPA safety factor is referred to as a population adjusted dose (PAD). A FQPA safety factor was retained as 10X to be applied to dietary risk assessments for atrazine. Therefore, the acute RfD used in the dietary assessment for one-day exposures to atrazine and the chlorinated metabolites was 0.1 mg/kg/day, and the acute population adjusted dose (aPAD) was 0.01 mg/kg/day. For the relevant population subgroup considered under the acute risk assessment, "females (13-50 years old)," the estimated exposure at the 99.9th percentile of exposure is 0.000041 mg/kg body weight/day, which is <1.0% aPAD. One-day exposures at the 99.9th percentile of exposure that are less than 100% of the aPAD are below HED’s level of concern for acute effects. Estimates of risk based on one-day (acute) exposures to atrazine and the chlorinated metabolites for the relevant subgroup is below HED's level of concern. Table 5 shows the results of the acute dietary risk assessment at various percentiles of exposure.

Table 5. Results of the Acute Assessment for Atrazine and its Chlorinated Metabolites

Population Subgroup	Exposure at 95% (mg/kg/day)	Exposure at 95% (%aPAD)	Exposure at 99% (mg/kg/day)	Exposure at 99% (%aPAD)	Exposure at 99.9% (mg/kg/day)	Exposure at 99.9% (%aPAD)
Females 13-50	0.000017	<1.0	0.000025	<1.0	0.000041	<1.0

Milk-based residues were the major contributor to acute exposure to atrazine and the chlorinated metabolites with meat-based residues the second major contributor. Because the residues in these commodities were estimated using the results of the animal feeding studies, the residues in meat and milk are expected to be conservative. Exposure predominates through the transfer of residues to meat and milk foods because concentrations of atrazine and the chlorotriazine metabolites occur primarily on the crop parts used as animal feeds, i.e., the stems and leaves of corn and other crops. With the exception of wheat, residues are not found in the grains and nuts treated with atrazine, the crop parts eaten by humans. Residues of atrazine also do not appear to be found in sugar cane or in refined cane sugar. Although a tolerance level residue was used for guava and ½ of the LOD for each compound was used for macadamia nuts, these commodities are insignificant food items in the diet, and have a corresponding insignificant impact on the dietary exposure to atrazine. The dietary exposure model inputs and complete acute analysis are appended to Attachment V.

4.2.3 Chronic Dietary Risk Estimate

As previously summarized, chronic dietary exposure assessments were performed for atrazine and its chlorinated metabolites. As per OPP policy, a reference dose (RfD) modified by an FQPA safety factor is referred to as a population adjusted dose (PAD). A FQPA safety factor was retained as 10X to be applied to dietary risk assessments for atrazine. Therefore, the chronic RfD used in the assessment was 0.018 mg/kg/day, and the chronic population adjusted dose (cPAD) was 0.0018 mg/kg/day. Average exposures less than 100% of the cPAD are below HED's levels of concern for chronic effects. Risk estimates for all subgroups analyzed were less than 1% of the chronic population adjusted dose (cPAD), and therefore risk estimates for all subgroups are below HED's level of concern. The estimate of chronic dietary exposure and risk for the seven most-highly exposed population subgroups from uses of atrazine on food/feed crops are summarized in Table 6. The dietary exposure model inputs and complete chronic analysis are appended to Attachment V.

Table 6. Results of the Chronic Assessment for Atrazine and its Chlorinated Metabolites

Population Subgroup	Exposure (mg/kg/day)	Exposure %cPAD
General Population	0.000005	<1.0
Infants	0.000008	<1.0
Children 1-6	0.000017	<1.0
Children 7-12	0.000009	<1.0
Females 13-50	0.000003	<1.0
Males 13-19	0.000006	<1.0
Males 20+	0.000003	<1.0
Seniors	0.000003	<1.0

As was the case for acute dietary exposure, the major contributors to chronic exposure to atrazine and the chlorinated metabolites were meat and milk for the aforementioned reasons. Grains eaten by humans, refined sugar, guava and macadamia nuts have an insignificant impact on exposure to atrazine and the chlorinated metabolites in the diet.

In addition, a chronic dietary exposure assessment was performed for the hydroxy-metabolites of atrazine. Available data on exposure to hydroxyatrazine is limited to the oral route. Because the FQPA safety factor was reduced to 1X for the hydroxy-metabolites of atrazine, the chronic RfD for the hydroxyatrazine (0.01 mg/kg/day) is equal to the chronic PAD. All population subgroups had exposures below their respective cPADs. Risk estimates for all subgroups analyzed were less than 1.0% of the chronic population adjusted dose (cPAD), and therefore risk estimates for all subgroups are below HED's level of concern. "Children, one to six years old," were the most highly exposed subgroup for chronic exposure assessment for the hydroxy-metabolites at 0.000059 mg/kg/day. The results of the chronic dietary exposure assessment for the hydroxy-metabolites are provided in Table 7.

Table 7. Results of the Chronic Assessment for the Hydroxy-Metabolites of Atrazine

Population Subgroup	Exposure (mg/kg/day)	Exposure %cPAD
General Population	0.000025	<1.0
Infants	0.000056	<1.0
Children 1-6	0.000059	<1.0
Children 7-12	0.000045	<1.0
Females 13-50	0.000019	<1.0
Males 13-19	0.000032	<1.0
Males 20+	0.000018	<1.0
Seniors	0.000014	<1.0

As can be seen from these tables, estimated exposures to the hydroxy-metabolites of atrazine in food though minimal are greater than estimated exposures to atrazine and the chlorinated metabolites in food. This is expected as the hydroxy-metabolites of atrazine are the dominant plant metabolites of atrazine. For all population subgroups, corn was the major contributor for chronic exposure to the hydroxy-metabolites. The residues estimated on corn are also conservative because ½ LOD value from the field trials was used for each of the two hydroxy-metabolites analyzed for in field trial samples of corn grain, rather than the more sensitive metabolism data. Field trial data were used because one of the four hydroxy-metabolites of atrazine was detected above the LOD in one sample of corn in monitoring data collected under the PDP.

4.2.4 Risk Characterization and Sources of Uncertainties

HED considers the dietary estimates of risk associated with food exposures to be conservative. There was adequate information about concentrations of atrazine and the chlorotriazine metabolites in all of the major crops, but it must be noted that only very limited data of any kind was available for guava and macadamia nuts. Virtually all of the information for these latter two crops is uncertain, but neither of these two crops contributes much to overall dietary exposure. Sensitivity analyses showing the effects of removing these two crops from the exposure assessments altogether had almost no effect. There was adequate information to estimate residues in meat and milk using the results of animal feeding studies, but these estimates are expected to be conservative.

The only monitoring data available from PDP or FDA that was used in this assessment was on wheat grain. For the most part, only the parent atrazine has been monitored by FDA or PDP, and there has been sparse monitoring data for all the crops except sweet corn and wheat grain. Where monitoring data existed, no residues were detected except in wheat grain (and in isolated spinach and lettuce samples). (One sample of a cooked chicken breast was also found positive for atrazine at 0.001 ppm in the FDA Total Diet Survey. No other residues of atrazine were found in all of the Total Diet Study sampling over the years 1991 through 1999.)

Because no residues of atrazine were detected on corn or sorghum grain in monitoring or in field trials, residues in corn and sorghum grain could be more accurately estimated from the metabolism studies. Metabolism studies were more accurate because these assays provided much more sensitive estimates of concentrations of atrazine and the chlorotriazine metabolites than the monitoring or field trial testing. Even so, these estimates are conservative since the anticipated residue of atrazine and the chlorinated metabolites are less than the total radioactive residues (TRR) measured in the organic extracts from metabolism studies that were used in the dietary assessments.

In 1997 FDA detected illegal residues of atrazine in six lettuce products from Florida: (one endive, one iceberg lettuce and four Romaine lettuce samples) ranging from a trace to 45 ppb. PDP also detected illegal residues of atrazine in four spinach samples from New York in 1995-1996. Neither the residues on spinach nor on lettuce contribute significantly to dietary exposure, and these crops were not further investigated in this assessment. Wheat samples collected by PDP also had higher residues of parent atrazine than expected from field trials in slightly more (1.7 percent) than theonepercent expected based on estimates of percent of the wheat crop treated (one percent) by BEAD. The residues on wheat do make a significant contribution to exposure, but HED has no concrete evidence to explain why the residues on wheat are larger than expected. While wheat is a significant source of exposure, it is not the major contributor to the risk estimates.

Sensitivity analyses were also performed for both assessments of atrazine and it's chlorinated metabolites, and for the chronic assessment for hydroxyatrazine. This was done to estimate the uncertainty from the incorporation of nondetectable residues on crops into the dietary assessment. Setting all nondetectable results were set to zero in these sensitivity analyses impacted the risk estimates insignificantly. The results of these sensitivity analyses can be found in Attachment V (attachments 6.a, 6.b, and 6.c of HED memorandum on "Anticipated Residues and Acute and Chronic Dietary Exposure Assessments for Atrazine," 01/18/01, D. Soderberg & C. Eiden, D272010).

4.3 Drinking Water Exposure and Risk Assessment

4.3.1 Drinking Water Standards

Atrazine is currently regulated under the Safe Drinking Water Act (SDWA). A Maximum Contaminant Level (MCL) of 3 ppb was established in 1991 by the Agency's Office of Water (OW). The OW has also established a One-Day Health Advisory Level (HAL) of 100 ppb for one-day exposures to atrazine in drinking water.

4.3.2 Environmental Fate and Occurrence

Atrazine is the most commonly detected pesticide in ground and surface water. It has been the subject of multiple monitoring programs conducted by the registrant, academia, states, and government agencies, in particular the U.S. Geological Survey (USGS). Atrazine's frequent detection in streams, rivers, groundwater, and reservoirs is related directly to both its volume of usage, and its tendency to persist in soils and move with water. Atrazine contamination of surface waters from normal agricultural use occurs through runoff from treated fields, spray drift from fields adjacent to sources of surface water, irrigation, flooding, and unintended atmospheric transport in precipitation. Residues reach groundwater through a slow and steady process of leaching.

Atrazine is metabolized in soil and water to form desethyl atrazine, desisopropyl atrazine, and ultimately the terminal metabolite, diaminochlorotriazine (DACT). DACT has been measured in concentrations equal to atrazine, *per se*, in rural wells, and is believed to be at least as persistent as the parent once formed. The hydroxy-metabolites of atrazine are not expected to occur in water in concentrations as significant as the chlorinated metabolites.

4.3.3 Monitoring Data

There are more monitoring data for atrazine, *per se*, from studies designed to assess ambient water quality available than for any other pesticide. There are also more monitoring data on atrazine, *per se*, in sources of drinking water and finished drinking water than for any other pesticide. The quality of the database for assessing exposures to atrazine, *per se*, in drinking water relative to other pesticides is very high. However, data on the chlorinated metabolites are limited. Typically, in the absence of reliable, appropriate, and available monitoring data, OPP uses water quality models to provide screening-level estimates of pesticide concentrations in surface water and groundwater. Because monitoring data on finished drinking water are available for atrazine from a variety of monitoring programs, OPP has used these data as the basis of the drinking water assessment in lieu of the models.

The risk assessments for drinking water exposures to chlorotriazines fall into three categories: (1) CWS using surface water in 21 states with major atrazine use; (2) CWS using groundwater sources in 21 states with major atrazine use; and (3) domestic rural wells in high-use areas for atrazine.

a. Compliance Monitoring Data

There are 54,367 CWS supplying drinking water in the U.S. of which 43,607 use groundwater and 10,394 use surface water. Compliance monitoring data under the SDWA have been collected on atrazine, *per se*, for about 10 years on a portion of these. Monitoring waivers may be granted to a specific CWS if atrazine is not detected after consecutive monitoring across three quarters in a given year, and/or if there is documentation of no atrazine use in areas affecting the CWS. This means there are CWS currently not monitoring for atrazine[2]. Compliance monitoring data do not include analyses for the chlorinated metabolites of atrazine.

The registrant has compiled compliance monitoring data collected on atrazine under the SDWA from 1993 through 2000 for 21 states with major atrazine use from state agency monitoring records. This database is called the Population Linked Exposure Database (PLEX) because it cross-links each community water system (CWS) sampled under compliance monitoring with the population it serves. Monitoring data from each CWS located within the 21 states with major atrazine use are included in the database unless a CWS received a monitoring waiver.

[2] Part 2 EPA, 40 CFR Parts 141, 142, 143, Volume 56, No. 20, Wednesday January 30, 1991, pp. 3585-3586, " National Primary Drinking Water Regulations Final Rule."

The PLEX includes monitoring data on atrazine from 21,241 CWS, using either surface water (3670 CWS) or groundwater (16,865 CWS) or a blend of both (706), in 21 states with major atrazine use accounting for 92 percent of all atrazine used in the U.S. Data on atrazine from PLEX for exposure assessment are available for ~33 percent of the surface and groundwater CWS in the U.S. The 21 states included in PLEX are: California, Delaware, Florida, Hawaii, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Michigan, Minnesota, Missouri, Nebraska, New York, North Carolina, Ohio, Pennsylvania, Texas, and Wisconsin. This database provides information on the exposure of approximately 120,000,000 people (roughly 43 percent of the U.S. population) to concentrations of atrazine and the chlorotriazine metabolites in their drinking water. The CWS contained in the PLEX database are the CWS expected to have the highest potential impacts resulting from atrazine use. Of these 21,241 CWS monitoring for atrazine from 1993 through 1999, approximately 11 percent (2,386 CWS) had one or more detections of atrazine above limits of quantitation (LOQs) for atrazine. The LOQs used range from 0.01 to 0.5 ppb. The majority of these CWS are surface water systems. Because the SDWA only requires analysis for atrazine, *per se*, this database does not contain residue data on atrazine's chlorinated metabolites. Because PLEX includes those CWS detecting concentrations of atrazine, the Environmental Fate and Effects Division (EFED) has reported the PLEX database to be conservatively biased. At the most, CWS included in the PLEX were sampled once quarterly (four times per year) as mandated under the SDWA. Because of the infrequency of the sampling, these data may be used reliably to estimate an annual mean concentration of atrazine in finished drinking water, but not one-day, short-term, or intermediate-term concentrations over days, weeks or months. Therefore, this database is most useful for developing exposure assessments based on chronic toxic effects. A detailed discussion of the PLEX database can be found in Attachment VII.

b. Targeted CWS using Surface Water with High-End Exposures’

Based on the results of the compliance monitoring, the registrant initiated a program designed to monitor a subset of those CWS identified in the PLEX database with a history of contamination problems. This targeted monitoring program, which includes CWS on a voluntary basis, is called the Voluntary Monitoring Survey (VMS), and has been ongoing since June 1993. Generally, the CWS included in the VMS had exceeded the MCL for atrazine of 3 ppb, or were small reservoirs that drain agricultural watersheds with a history of substantial atrazine use. Consequently, the VMS database is conservatively biased. For CWS included in the program in any given year, finished water samples were collected and analyzed weekly during the months of May, June, and July. Samples were collected biweekly for the remainder of the year. As of 2000, there were 101 CWS included in the VMS representing nine high-atrazine use states: Illinois, Indiana, Iowa, Kentucky, Kansas, Louisiana, Missouri, Ohio, and Texas. All of the 101 CWS included in the VMS provide drinking water from surface water sources. The registrant analyzed the finished water samples for atrazine, *per se*, and did not include the chlorinated metabolites. Because of the frequency of the sampling, these data may be used reliably to estimate one-day, short-term, intermediate-term (seasonal) and annual mean concentrations of atrazine in finished drinking water. Therefore, this database is useful for developing exposure assessments based on acute, short-term, intermediate-term (subchronic), and chronic effects. Data from all 101 CWS included in the VMS through 2000 were included in this drinking water assessment. A detailed discussion of the VMS database can be found in Attachment VII.

The Aceotochlor Registration Partnership (ARP) was developed as a condition of registration for acetochlor. However, the ARP has also analyzed for atrazine, *per se.* This monitoring program is based on a random, but stratified survey design, in which the largest number of CWS included in the survey represent CWS draining small watersheds with a relatively high percentage of the watershed cropped to corn. The ARP includes 175 CWS in 12 states using surface water as their source. Monitoring data from the ARP were available from 1995 through 1998. This represents a second targeted monitoring program for CWS using surface water located either in high atrazine use areas or in watersheds with a relatively high percentage of corn agriculture. As in the case of the VMS, the frequency of the sampling in the ARP allows the estimation of peak, seasonal and annual mean concentrations of concentrations of atrazine in finished drinking water. This database is also useful for developing exposure assessments based on both acute, short-term, intermediate-term, and chronic effects. A detailed discussion of the ARP database can be found in Attachment VII.

c. Targeted CWS Using Surface Water Monitored for Atrazine and the Chlorinated Metabolites

At the request of the Agency, the registrant provided some residue data on the chlorinated metabolites of atrazine in CWS using surface water as their source. Finished drinking water from a subset of 17 CWS included in the VMS, which is also a subset of CWS in the PLEX database, were sampled from August 1997 through July 1998. Samples were collected monthly August through April and biweekly in May, June, and July, and analyzed for atrazine, and each of its chlorinated metabolites: desethyl atrazine, desisopropyl atrazine, and diaminochlorotriazine (DACT). The EFED developed linear regression equations from these data to estimate concentrations of the chlorinated metabolites in the other CWS in the VMS, the PLEX, and the Aceotochlor Registration Partnership (ARP) database. A detailed discussion of the regression approach to estimating concentrations of the chlorinated metabolites in CWS using surface water can be found in Attachment VII.

d. Rural Wells Targeted for High-End Exposures

The registrant has also provided a database containing residue data on atrazine, its chlorinated metabolites, and its four hydroxy-metabolites for 1,505 private, rural drinking water wells in 19 states with major atrazine use called the Rural Well Survey. These wells were sampled during September 1992 to March 1995. These wells were selected in conjunction with the Department of Agriculture for each state included in the survey. The wells were selected based on their proximity to farms growing corn, and general location in atrazine use areas, as well as depth to water. This database represents rural wells targeted for their location in atrazine use areas. Each well was sampled one time only, and analyzed for atrazine, desethyl atrazine (DEA), desisopropyl atrazine (DIA), diaminochlorotriazine (DACT), hydroxyatrazine, desethylhydroxyatrazine, desisopropylhydroxyatrazine, and diaminohydroxyatrazine. Because only one sample per well has been taken and analyzed, exposure to concentrations of atrazine and the chlorotriazine metabolites in these private rural wells for acute and chronic effects has necessarily been based on a single concentration value. This database is most useful for estimating exposures to that portion of the population that get their drinking water from domestic rural wells located in close proximity to areas of atrazine use.

e. Targeted CWS Using Groundwater Monitored for Atrazine and the Chlorinated Metabolites

Syngenta performed a "synoptic" groundwater survey of groundwater CWS in 21 states with major atrazine-use. The survey was designed to estimate the 95th percentile exposure from two strata of CWS wells: wells with at least one detection of atrazine prior to 1998, and wells with no previous detections of atrazine. A total of 204 wells were selected from the first stratum, which represented the 418 total CWSs with previous detections, serving two million people. In effect, 50 percent of the CWS with prior detections of atrazine have been sampled once for the chlorotriazines. A total of 235 CWSs were selected from the second, which represented 14,115 CWSs serving 20.5 million people. Syngenta reported maximum sample values for these two strata as 0.73 ppb for the "nondetect" group, and 2.29 ppb for the "detect" groups for atrazine and chlorinated metabolites. One value of ~10 ppb was thrown out because the well is being investigated "for point source issues." (Subsequent monitoring at another well in the same CWS gave nondetectable residues.)

f. Monitoring Data Summary

In summary, monitoring data were available to estimate exposures to atrazine and the chlorinated metabolites for three distinct population subgroups: populations served by CWS using surface water in the 21 states with major atrazine use (64,943,203 people), populations served by CWS using groundwater in the 21 states with major atrazine use (55,440,483 people) and populations using private rural wells located in atrazine use areas for their drinking water (10 percent of the population). These monitoring data represent drinking water for approximately 43 percent of the U.S. population. Additionally, HED has conducted a refined exposure assessment for those populations served by CWS using surface water targeted as having concentrations of atrazine and the chlorotriazine metabolites considered to represent "high-end" exposures via the VMS and ARP databases.

Monitoring data from all of these databases were used in the exposure assessment for concentrations of atrazine and the chlorotriazine metabolites in drinking water. Data from the PLEX database have been used to estimate national exposures based on peak one-day concentrations and annual average concentrations of atrazine and the chlorinated metabolites. Because the VMS and ARP data represent CWS targeted for high atrazine use and contamination, data from these programs were used to estimate "high-end" exposures for people served by CWS using surface water in atrazine use areas based on the measured maximum one-day to weekly concentrations, annual average concentrations, and quarterly (90-day) mean concentrations (based on the highest 90-day average concentration) of atrazine and the chlorinated metabolites in each CWS. Data from the registrant's rural drinking water well survey were used to estimate exposures to atrazine and the chlorinated metabolites of individuals living in areas with high atrazine use and using rural wells adjacent to corn fields.

4.3.4 Exposure Assessment Methodology

Exposure assessments for chlorotriazines have been conducted for CWS and rural wells covered under the previously described databases. Because the sheer volume of available monitoring data for CWS is very large, HED developed an approach involving an initial screening-level assessment for all CWS and wells for which data on atrazine and the chlorinated metabolites were available, followed by a probabilistic assessment for all CWS identified as of concern under the screening-level methodology. This approach was developed to allow for the most efficient use of resources within OPP. Using OPP resources to conduct probabilistic exposure assessments for each CWS using all of the data contained in the PLEX, VMS, and ARP databases was prohibitive. Because of the limited data on each of the rural wells included in the Rural Well Survey (one sample), a probabilistic assessment for each well identified under the screening-level assessment is not possible.

Screening-level exposure assessments have been conducted for maximum one-day (acute), 90-day average (intermediate-term), and annual average (chronic) exposures to residues of atrazine and the chlorinated metabolites in CWS using surface water. Under the screening-level assessments, for each surface water CWS for which data were available, estimates of maximum and annual average concentrations of the chlorotriazines were estimated. Quarterly (90-day) average concentrations were estimated for a subset of these surface water CWS. Because only one to two concentration values for atrazine and the chlorinated metabolites were available for rural wells and CWS using groundwater, these values were used to represent both maximum and average concentrations. These concentration estimates were compared to drinking water levels of comparison (DWLOCs) for acute and intermediate-term and chronic effects.

A DWLOC is the portion of the acute PAD or chronic PAD remaining after estimated dietary (food only) exposures have been subtracted that has been converted to a concentration (ppb). This concentration value (DWLOC) represents the available or allowable exposure through drinking water for atrazine and the chlorinated metabolites. Under the acute risk assessment for drinking water, the remaining portion of the acute PAD is based on dietary exposures at the 99.9th percentile of exposure for each relevant population subgroup considered. Maximum concentrations of chlorotriazines less than an acute DWLOC of 298 ppb do not exceed HED's level of concern for acute effects. Under the intermediate-term and chronic risk assessments for drinking water, the remaining portion of the chronic PAD is based on average dietary exposures for each relevant population subgroup considered. Annual and seasonal average concentrations of chlorotriazines less than a DWLOC of 12.5 ppb do not exceed HED's level of concern for intermediate-term and chronic effects. DWLOC values vary for population subgroups depending on dietary exposure through foods for each subgroup, and the assumptions made about drinking water consumption, and body weights for each subgroup.

See Appendix I for details of the screening-level methodology.

4.3.5 Risk Estimates based on Screening-Level Exposures Assessments for Residues of Atrazine and the Chlorinated Metabolites in Drinking Water

Community Water Systems (CWS) Using Surface Water

a. Acute (One-Day) Exposures

The maximum measured concentrations of atrazine and the chlorinated metabolites detected in each of 3670 CWS using surface water (as contained in the PLEX, the VMS, and the ARP databases) were compared to the acute DWLOC value for females 13 to 50 years old (the relevant population subgroup). Because all of the one-day maximum concentrations of chlorotriazines at each CWS from each database are well below the DWLOC value for acute effects, 298 ppb, HED has no concerns regarding acute effects from one-day exposures to atrazine and the chlorinated metabolites in drinking water from CWS using surface water. The maximum concentration measured in any CWS was 89 ppb. Based on the available data, OPP does not expect maximum one-day concentrations of atrazine and the chlorinated metabolites to exceed 298 ppb. Table 1 of Appendix I contains the name of the CWS in each database with the highest one-day concentration, the population served by that CWS, and the year that the maximum concentration occurred.

b. Intermediate-Term (30 days to six months) to Chronic Exposures (six months to lifetime)

Under the screening-level assessment for intermediate-term and chronic effects, 29 CWS out of 3670 were identified (see Tables 6 and 7 in Appendix I) for probabilistic assessment based on a comparison of average seasonal concentrations of atrazine and the chlorinated metabolites to a DWLOC value of 12.5 ppb. These 29 CWS were identified with quarterly average concentrations of chlorotriazines above levels of concern (approaching, equal to, or greater than 12.5 ppb) for infants in one, two, or three years between 1993 through 2001. They represent variously 0.14 percent of the ~21,000 CWS in 21 states with major atrazine use monitoring for atrazine under the SDWA using either surface or groundwater or a blend, 0.59 percent of the 4,886 CWS using surface water only, and 0.79 percent of the 3670 CWS using surface water only with data on atrazine. These CWS are: Gillespie, Hettick, Shipman, Salem, Palmyra-Modesto, Hillsboro, Farina, Kinmundy, ADGPTV, Carlinville, West Salem, Flora, Sorento, White Hall, Centralia, and Wayne City in Illinois, Chariton in Iowa, Iberville in Louisiana, Batesville, Holland, North Vernon, and Scottsburg in Indiana, Lewisburg and Marion in Kentucky, Bucklin, Dearborn, Drexel, and Vandalia in Missouri, and Sardinia in Ohio. These 29 CWS are monitored under the SDWA for atrazine, and they serve approximately 135,000 people of which 6.8 percent (2000 Census) are five years old or younger, and 1.4 percent are one-year-old or less. In addition, another 52 CWS were identified for targeted monitoring. (See Appendix III).

Eleven of these 29 CWS had annual average concentrations that exceed levels of concern for children. HED notes that the Shipman reservoir (serving approximately 650 people) no longer serves as a drinking water source; in 1999 the town of Shipman was switched to an alternative source of drinking water. The drinking water source at Whitehall was switched from surface water to groundwater in 1997.

Rural Wells

c. Acute and Chronic Risk Estimates for Rural Wells

Only one well sample was available initially for each rural well sampled. This concentration value was used as an estimate of maximum and average concentrations of chlorotriazines in each rural well. The highest measured concentration from any well in the Rural Well Survey was 18 ppb. For individuals using private rural wells, HED has no concern for acute effects as a result of one-day maximum exposures to atrazine and the chlorinated metabolites under either of the screening-level approaches used to estimate acute risk. HED notes that it is highly unlikely that under normal agricultural uses that concentrations of atrazine and the chlorotriazine metabolites would exceed a maximum one-day concentration of 298 ppb in a given well. For adults, there are no concerns for chronic exposures to concentrations of atrazine and the chlorotriazine metabolites in rural wells. Based on the newly recommended average body weights for infants (< one year old) eight rural wells out of the 1,505 sampled once had concentrations of atrazine and the chlorinated metabolites of 12.5 ppb or greater. These eight wells were resampled in March 2001, one sample per well. All samples showed concentrations of atrazine and the chlorinated metabolites less than 12.5 ppb. Although the data indicate that levels are decreasing in these wells over time, there are still concerns for subchronic and chronic exposures of infants using private rural wells in close proximity to atrazine use areas. It is difficult to interpret typical exposures in rural wells close to atrazine use areas based on two samples taken many years apart.

d. Acute and Chronic Risk Estimates for CWS Using Groundwater

Previously, HED concluded that CWS using groundwater are not impacted nearly as heavily by atrazine use as CWS using surface water. This was based on a partial assessment (contained in Attachment VII) using the available compliance monitoring data collected under the SDWA on residues of atrazine, *per se*, in finished drinking water from CWS using groundwater in the 21 major atrazine use states serving 55,440,483 people. That assessment included data on 16,865 CWS using groundwater that were collecting data on atrazine under the SDWA or ~40 percent of the 43,607 groundwater CWS supplying drinking water to the U.S. public.

Since that time, data to estimate concentrations of the chlorinated metabolites of atrazine in CWS using groundwater have been developed. The registrant supplied a “synoptic” survey of CWS using groundwater. A total of 439 groundwater CWS were sampled once or twice and analyzed for total chlorotriazines. Of the 439 groundwater CWS sampled, 235 had no prior detections of atrazine, and 204 had prior detections of atrazine. The 235 groundwater CWS represent 14,000 CWS without prior detections serving 20.5 million people. The 204 groundwater CWS represent 418 CWS with prior detections serving two million people. Data from these 439 CWS represent 14,500 or ~33 percent of the 43,607 CWS using groundwater in the U.S. The survey was designed to estimate the 95th percentile chlorotriazine concentration in the wells analyzed with a standard error of 30 percent.

The highest concentration of atrazine and the chlorinated metabolites measured in any groundwater CWS well in the survey was ~11 ppb, which is less than the acute DWLOC of 298 ppb. The 99th percentile concentration value for chlorotriazines in CWS with prior detections of atrazine was 1.9 ppb. A 95th percentile upper confidence bound was not estimated around the 99th percentile value. Both the maximum measured value and the 99th percentile value are less than the acute DWLOC of 298 ppb. Although there is some uncertainty that an estimate of the maximum chlorotriazine concentration in groundwater CWS has been made and that all CWS using groundwater with relatively high levels of atrazine and the chlorinated metabolites have been identified, HED notes that approximately 50 percent of the groundwater CWS with prior detections of atrazine have been sampled, and therefore HED has high confidence that exposures to atrazine and the chlorinated metabolites is low in CWS using groundwater.

The 50th percentile concentration value was 0.180 ppb for wells with prior detections, which is less than the lowest intermediate-term to chronic DWLOC of 12.5 ppb. The mean concentration value at the 95 percent upper confidence bound was 0.55 ppb for CWS with prior detections. Both concentration values the 50th percentile and the mean are less than the lowest intermediate-term to chronic DWLOC of 12.5 ppb, and do not exceed HED's level of concern for chronic effects.

The 418 CWS using groundwater with prior detections of atrazine represent ~onepercent of the 43,607 groundwater CWS in the US supplying public drinking water. In contrast, approximately 41 percent of CWS using surface water in the 21 major use states serving 25 million people had detections of atrazine and the chlorotriazine metabolites in finished drinking water. Although this synoptic survey for CWS using groundwater is considered incomplete until further statistical analyses are run on the study data, in general, the results support HED's previous conclusion that CWS using groundwater are not impacted as heavily by atrazine use as CWS using surface water and rural wells.

4.3.6 Risk Estimates based on Probabilistic Exposures Assessments of Residues of Atrazine and the Chlorinated Metabolites in Drinking Water

28 CWS using Surface Water

Probabilistic exposure assessments were conducted for 28 CWS most of which were identified as of concern under a screening-level assessment using a screening-level approach. Risk estimates based on a probabilistic exposure assessment that estimated 90-day average exposures to atrazine and the chlorinated metabolites indicate that 25 CWS still have seasonal concentrations that exceed levels of concern for infants at the maximum 99.9th percentile of exposure. In addition, four CWS for which exposures were assessed deterministically, but not probabilistically, have seasonal concentrations of atrazine and the chlorinated metabolites that exceed levels of concern for infants.

In total, 29 CWS (assessed either deterministically or probabilistically) had 90-day average exposures to atrazine and the chlorinated metabolites that exceed levels of concern for infants in one, two, or three years between 1993 and 2001. Risk estimates for these CWS ranged from 100% to 670% of the cPAD. Several of these CWS also exceed levels of concern at the maximum 99.9th percentile of exposure for children aged one to six years of age, and adults as well. These 29 CWS are: Gillespie, Hettick, Salem, Palmyra-Modesto, Hillsboro, Farina, Kinmundy, ADGPTV, Carlinville, West Salem, Flora, Sorento, White Hall, Louisville, and Centralia in Illinois, Chariton in Iowa, Iberville in Louisiana, Batesville, Holland, North Vernon, and Scottsburg in Indiana, Lewisburg and Marion in Kentucky, Bucklin, Dearborn, Drexel, and Vandalia in Missouri, Newark, and Sardinia in Ohio. (Table 1 in Appendix II). They serve approximately 180,000 people of which 6.8 percent (2000 Census) are five years old or younger, and 1.4 percent are one-year-old or less. Seasonal pulses of atrazine and the chlorinated metabolites resulting in exposures of concern at these CWS spanned several weeks to several months. Typically, for the year with exposures of concern, pulses lasted from early spring through summer and into the fall at many of the CWS. Some CWS had high pulses almost all year long. The higher concentrations occurring in the spring and early summer influence the 90-day average concentrations all year long. (See Table 4 in Appendix II).

Although informative, probabilistic assessments of exposure for other exposure periods were not considered necessary and are not discussed in this document, because risk estimates for these other durations of exposure assessed under HED's screening-level exposure assessments in the revised preliminary assessment did not exceed HED's level of concern.

4.3.7 Risk Estimates for Atrazine's Hydroxy-Metabolites in Drinking Water

Exposure assessments have not been conducted for the hydroxy-metabolites of atrazine because of the limited data available, and EFED has determined that although occasional contamination of surface waters by hydroxy concentrations of atrazine and the chlorotriazine metabolites cannot be ruled out, in general, hydroxyatrazine is unlikely to contaminate surface water to the same degree as atrazine and some of the chlorinated metabolites. However, HED has compared the lowest chronic DWLOC calculated for hydroxyatrazine (99 ppb) to concentration values expected and/or measured for atrazine's hydroxy-metabolites in surface water and groundwater to provide a qualitative estimate of exposure to atrazine's hydroxy-metabolites in drinking water.

HED notes that the lowest chronic DWLOC for hydroxyatrazine is 99 ppb (based on current OW default values defaults for body weight for children and infants of 10 kg) or 69 ppb (based on a default body weight of 7 kg for infants less than one-year-old). As average annual concentrations of hydroxyatrazine are not expected to exceed those of atrazine and the chlorinated metabolites in surface water, it is unlikely that average annual concentrations of the hydroxy concentrations of atrazine and the chlorotriazine metabolites would exceed 20 ppb (the maximum measured time-weighted annual average concentration for atrazine and the chlorinated metabolites in a CWS using surface water) as seen in Table 3. Therefore, HED does not expect average annual concentrations of the hydroxy-metabolites in finished drinking water from CWS using surface water to exceed the lowest chronic DWLOC for chronic effects of 99 ppb. This is the concentration of the hydroxy-metabolites of atrazine in drinking water that are not expected to result in adverse health effects for children once average exposures to the hydroxy-metabolites in food are considered. As the highest concentration of hydroxy-metabolites in rural wells was 7.66 ppb, HED does not expect concentrations of the hydroxy-metabolites in finished drinking water from CWS using groundwater or in private rural wells to be of concern. Based on the chronic DWLOC for hydroxyatrazine, and available but limited data, exposures to hydroxy-metabolites in finished drinking water are expected to be an insignificant contributor of risk.

4.3.8 Risk Characterization and Sources of Uncertainty

a. Atrazine and the Chlorinated Metabolites

Because people receive their drinking water from various sources, i.e., CWS using either surface water, groundwater, or a blend, and private rural wells, and the estimated risks associated with exposure to concentrations of atrazine and the chlorotriazine metabolites in drinking water are presented by drinking water source, the following uncertainty discussion is by drinking water source category, as well. Risk estimates presented in this document that are based on screening-level methodologies are considered to be conservative. HED believes these risk estimates to be conservative because the exposures have been estimated using a single, fixed residue value, a point estimate of either a maximum value for acute effects or an average value for intermediate-term and chronic effects, is assumed along with 90^{th} percentile default drinking water consumption rates, and average body weights for individuals in each population subgroup considered in the assessment.

Risk estimates based on probabilistic methodologies for CWS identified under the screening-level approach are considered highly refined.

In general, this assessment for exposures to atrazine and the chlorinated metabolites in drinking water is based on a solid foundation of available, reliable, and appropriate monitoring data relative to exposure assessments for most pesticides in drinking water. HED has a moderate level of confidence in the estimates of risk for people using surface water-sourced CWS as captured under the SDWA monitoring programs (PLEX). However, there is some uncertainty because the SDWA PLEX database, although large, is not comprehensive. It represents CWS in 21 major use states, but not all states with atrazine usage, and consequently, not all potential exposures to atrazine. There are individuals receiving drinking water from sources serving less than 25 people that are not regulated under the SDWA, and therefore, no monitoring data were available for the populations served by these CWS. The frequency of monitoring under the SDWA (quarterly) is insufficient to ensure detection of all CWS using surface water with high seasonal concentrations of atrazine. Although HED believes it likely that the CWS with the highest exposures have been identified, there is uncertainty that all CWS with high seasonal exposures have been identified based on the PLEX.

HED has a very high level of confidence in the estimates of risk for people using surface water-sourced CWS as captured under the intensive monitoring programs (VMS and ARP). However, a CWS was selected for inclusion in the VMS based on high concentrations of atrazine, *per se,* as monitored under the SDWA. As noted above, the infrequency of sampling under the SDWA makes it unlikely that all CWS with high seasonal concentrations of atrazine and the chlorinated metabolites have been identified.

Because PLEX includes those CWS detecting concentrations of atrazine, the Environmental Fate and Effects Division (EFED) has reported the PLEX database to be conservatively biased. Both the VMS and the ARP programs are strongly conservatively biased. The VMS program includes only those CWS targeted as having the highest concentrations of atrazine based on the PLEX data, and are associated with contamination problems. The VMS was designed to partially offset the negative bias introduced into the PLEX database as a result of the infrequent sampling required under the SDWA. Although CWS selected for inclusion into the ARP program were chosen randomly, a stratified design was used to over select for CWS located in small watersheds with high atrazine use. Because of the way in which CWS were selected for inclusion into the VMS and ARP programs, and the more frequent sampling schedule used in the VMS and ARP, the CWS in these two databases represent a high quality data set for estimating the high-end of exposures to concentrations of atrazine and the chlorotriazine metabolites expected in CWS using surface water.

There are CWS (52) using surface water monitored under the SDWA with quarterly maximum measured concentrations of atrazine and the chlorinated metabolites $\geq$12.5 ppb (the DWLOC value for intermediate-term and chronic effects for infants and children's groups, but whose annual average concentrations are below 12.5 ppb that were not included in either of the more intensive sampling programs sponsored by industry. Because of the infrequency of monitoring under the SDWA, there are no seasonal mean concentrations for these CWS to compare to DWLOC values for intermediate-term effects. These CWS may have seasonal mean concentrations either above or below 12.5 ppb. Although a direct comparison of these maximum measured concentrations to a DWLOC value based on intermediate-term and chronic effects would be inappropriate, this finding introduces another source of uncertainty into this risk assessment as it cannot be known from the available data if these CWS have seasonal mean concentrations of concentrations of atrazine and the chlorotriazine metabolites above levels of concern. These CWS for which HED has residual exposure concerns are listed in Appendix III for OW use in consideration of any necessary actions for these CWS. HED also recommends they be included in the VMS program for more frequent monitoring.

There are approximately 10,000 CWS receiving waivers from the requirement to monitor for atrazine based on sequential sampling showing low to nondetectable residues of atrazine in finished drinking water or by showing that atrazine use is not expected to impact the CWS. However, the risk estimates provided in this document assume that the waivers granted to those CWS were justified, and insignificant exposure to concentrations of atrazine and the chlorotriazine metabolites from those CWS are expected.

For the portion of the U.S. population receiving their drinking water from rural private wells adjacent to atrazine use areas, there is high uncertainty associated with this risk estimate. The database represents potential high-end exposures of individuals to concentrations of atrazine and the chlorotriazine metabolites in private rural wells. This database is neither comprehensive nor were the wells included in this database chosen randomly. There are 13 million "household" wells in the U.S. and the survey sampled 1,505 of these. Because wells sampled under the Rural Well Survey were targeted based on their proximity to atrazine use areas, well depth, and accessibility giving this database a very conservative bias, risk estimates based on this database represent high-end exposures for individuals using rural wells. Because the wells were sampled only once, the possibility of missing higher one-day concentrations of concentrations of atrazine and the chlorotriazine metabolites in a well exists, in which case, the risk estimates given here may underestimate risk. However, HED notes that it is highly unlikely that under normal agricultural uses that concentrations of atrazine and the chlorotriazine metabolites would exceed a maximum one-day concentration of 298 ppb in a given well. The possibility of a long-term average being less than the single concentration value used gives the chronic exposure assessments a conservative bias. In general, there is uncertainty that all of the rural wells with high exposures have been identified and those identified have not been sampled frequently enough to assess intermediate-term exposures. It is difficult to interpret typical exposures in rural wells close to atrazine use areas based on two samples taken many years apart.

For the portion of the U.S. population receiving their drinking water from CWS using groundwater, there is some uncertainty that all CWS using groundwater with high residues have been identified. However, HED believes that CWS using groundwater are the least impacted by atrazine use relative to rural wells and CWS using surface water, and has the least concern for exposures through these systems.

b. Hydroxy-Metabolites

The main source of uncertainty regarding the hydroxy-metabolites of atrazine is the lack of monitoring data. However, given the likely concentrations of these compounds in drinking water relative to their toxicity, HED does not expect exposure to these compounds to pose a significant risk.

4.4 Residential Exposure and Risk Assessment

Atrazine is labeled for homeowner use to control weeds in turf grasses that are generally specific to the Southeast, i.e., zyosia, and bermuda grasses. Homeowners applying atrazine products to their lawns may be exposed to atrazine through their skin (dermal) and by inhaling dusts or sprays (inhalation) during application. Residential exposures to atrazine are expected to be short-term in duration from one day to a maximum of two to three weeks. Intermediate-term exposures greater than 30 days in duration are not anticipated from residential uses of atrazine. The following five residential handler exposure scenarios were evaluated:

(1) mixing, loading, and applying liquid formulations using a backpack sprayer;

(2) mixing, loading, and applying liquid and wettable powder formulations with a low pressure hand wand;

(3) mixing, loading, and applying liquid (ready-to-use) formulations with a hose-end sprayer;

(4) mixing, loading, and applying granulated formulations with a push-type spreader; and

(5) mixing, loading, and applying granulated formulations with a belly-grinder.

Toddlers (one to three years old) have the potential to be exposed to concentrations of atrazine and the chlorotriazine metabolites after application through a transfer of residues to the skin (dermally) and through incidental oral exposure routes, such as, hand-to-mouth, and soil and turf ingestion. Adults may be exposed dermally to atrazine after application. Risks associated with residential exposures are expressed as Margins of Exposure (MOEs). The target MOE of 300 or more was selected for residential exposures based on a 10X UF for intraspecies variation, and a10X UF for interspecies variation, and an additional 3X for concerns regarding the effect of the neuroendocrine mode of action on the development of the young. MOEs greater than 300 for adult and children do not exceed HED's level of concern, i.e., are not of concern.

4.4.1 Handler Exposure and Risk Estimates

Homeowners handling and applying atrazine are expected to receive short-term (one to 30 days) dermal and inhalation exposures typically one to several days per year. Intermediate-term exposures (30 days to months in duration) are not expected for homeowners applying and handling lawn care products containing atrazine.

For the purposes of incorporating short-term dermal exposures into risk assessments, HIARC selected an endpoint of 6.25 mg/kg/day based on delayed puberty as described above. The oral NOAEL of 6.25 mg/kg/day was adjusted for dermal exposure by use of a dermal absorption factor of six percent from a human study to provide a dermal NOAEL of 104 mg/kg/day. A 30-day special pubertal assay in which young male rats were dosed orally from postnatal days 23 through 53 (juvenile to peripubertal) showed evidence of delayed preputial separation based on a NOAEL of 6.25 mg/kg/day and a LOAEL of 12. 5 mg/kg/day. This study was considered appropriate because the duration of exposure in the study (30-days) matches the duration (up to 30 days) in the short-term dermal risk assessment, and the endpoint (delayed puberty in young males) represents a neuroendocrine effect consistent with the mode of action for atrazine. A human dermal absorption factor of six percent was applied to the NOAEL for this oral endpoint for dermal exposure assessment.

For the purposes of incorporating short-term inhalation exposures into residential risk assessments, the HIARC selected the same endpoint, 6.25 mg/kg/day. This assessment assumes that 100 percent of the inhaled dose is absorbed. Short-term inhalation and dermal exposures can be combined because the two exposure pathways share a common toxic effect, i.e., delayed puberty.

Exposure and risk for residential handlers (adults) were estimated in essentially the same way as for occupational workers using similar application methods. The risk estimates assume that residents wear short-sleeve shirts, short pants, shoes and socks, ut no gloves or respirators. The Standard Operating Procedures (SOPs) for Residential Exposure assessments (revised February 2001) and the Outdoor Residential Exposure Task Force (ORETF) were both used to estimate exposure and compared. ORETF data were only available for two of the five exposure scenarios: the hose-end sprayer and the push-type spreader. With the exception of the exposure scenario for the belly-grinder application of granular formulations over 0.5 acres, all residential handler short-term dermal and inhalation MOEs were greater than 300, and did not exceed HED's level of concern. The aggregate dermal + inhalation MOE for the belly-grinder application scenario based on application over 0.5 acre is 65. The MOEs for the other exposure scenarios ranged from 640 to 28,000.

Table 8 summarizes the results of the short-term exposures and risk estimates for homeowner applicators. Attachment VI contains the details of this assessment and the calculations used. Table 9 summarizes the results of exposure and risk assessments using ORETF data.

Table 8. Residential Short-Term Handler Risks to Atrazine

Exposure Scenario	Crop Type/Use	Application Rate[a] (lb ai/acre)	Amount Handled per Day[b] (acres)	PHED Unit Exposure		Daily Dose		MOEs		
				Dermal[c] (mg/lb ai)	Inhalation[d] (µg/lb ai)	Dermal[e] (mg/kg/day)	Inhalation[f] (mg/kg/day)	Dermal[g]	Inhalation[h]	Aggregate
Mixer/Loader/Applicator										
Backpack Sprayer (R1)	lawns	2	0.023	5.1	30	0.0034	0.000020	31,000	320,000	28,000
Low Pressure Handwand - Liquid Formulations (R2)	lawns	2	0.023	100	30	0.066	0.000020	1,600	320,000	1,600
Granulars with a Belly-grinder (R5)	lawns	2	0.023	110	62	0.072	0.00004	1,400	150,000	1,400
Granulars with a Belly-grinder (R5)	lawns	2	0.5	110	62	1.6	0.00089	66	7,100	65

Footnotes:

[a] Application rates are the maximum application rates determined from EPA registered labels.

[b] Amount handled per day values are EPA estimates of acreage treated, as found in the Residential SOPs draft December 1997; 0.5 acre lawn or 1000 ft^2 (0.023) acre spot treatment.

[c] Dermal unit exposure values from Residential SOPs draft December 1997. Baseline dermal exposure assumes short pants, short sleeved shirt, and no gloves. All scenarios are considered mixer/loader/applicators.

[d] Inhalation unit exposure values from the Residential SOPs draft December 1997 representing a no respirator scenario.

[e] Dermal daily dose (mg/kg/day) = daily unit exposure (mg/lb ai) ***X*** application rate (lb ai/acre) ***X*** amount handled per day (acres/day)/body weight (70 kg adult).

[f] Inhalation daily dose (mg/kg/day) = inhalation unit exposure (µg/lb ai) ***X*** application rate (lb ai/acre) ***X*** amount handled per day (acres/day) x conversion factor (1 mg/1,000 µg) / body weight (70 kg;).

[g] Dermal MOE = NOAEL (104 mg/kg/day based)/daily dermal dose (mg/kg/day).

[h] Inhalation MOE = NOAEL (6.25 mg/kg/day)/daily inhalation dose (mg/kg/day).

Table 9. Residential Short-Term Handler Risks to Atrazine (Using ORETF Unit Exposure Values)

Exposure Scenario	Crop Type/Use	Application Rate[a] (lb ai/acre)	Amount Handled per Day[b] (acres)	ORETF Unit Exposure		Daily Dose		MOEs		
				Dermal[c] (mg/lb ai)	Inhalation[d] (µg/lb ai)	Dermal[e] (mg/kg/day)	Inhalation[f] (mg/kg/day)	Dermal[g]	Inhalation[h]	Aggregate
Mixer/Loader/Applicator										
Hose-end (Dial-Type) Sprayer (R3)	lawns	2	0.5	11	16	0.16	0.00023	660	27,000	640
Granulars with a Push Type Spreader (R5)	lawns	2	0.5	0.68	0.91	0.0097	0.00001	11,000	480,000	11,000

Footnotes:

[a] Application rates are the maximum application rates determined from EPA registered labels.

[b] Amount handled per day values are EPA estimates of acreage treated found in the Residential SOPs draft December 1997. Baseline dermal exposure assumes short pants, short sleeved shirt, and no gloves clothing scenario. All scenarios are considered mixer/loader/applicators.

[c] Dermal unit exposure values from two Outdoor Residential Exposure Task Force ORETF (MRID 449722-01 and ORETF Study Number OMA003) studies. Unit exposure data (geometric mean values) were analyzed in two EPA draft memos, one dated October 19, 2000 "*A Generic Evaluation of Homeowner Exposure Associated with Liquid Pesticide Handling and Hose-End Application to Residential Lawns"* vol 6 of 6. The other data evaluation memo was also dated October 19, 2000 "*A Generic Evaluation of Homeowner Exposure Associated with Granular Turf Pesticide Handling and Application to Residential Lawns.*" Homeowner exposure was assessed in this table using a short sleeved shirt, short pants, no glove clothing scenario.

[d] Inhalation unit exposure values from the same ORETF studies cited in footnote c representing "no respirator" scenarios.

[e] Dermal daily dose (mg/kg/day) = daily unit exposure (mg/lb ai) ***X*** application rate (lb ai/acre) ***X*** amount handled per day (acres/day) / body weight (70 kg adult).

[f] Inhalation daily dose (mg/kg/day) = inhalation unit exposure (µg/lb ai) ***X*** application rate (lb ai/acre) ***X*** amount handled per day (acres/day) ***X*** conversion factor (1 mg/1,000 µg)/body weight 70 kg).

[g] Dermal MOE = NOAEL (104 mg/kg/day) / daily dermal dose (mg/kg/day).

[h] Inhalation MOE = NOAEL (6.25 mg/kg/day) / daily inhalation dose (mg/kg/day).

4.4.2 Post Application Exposures and Risk Estimates

Post application dermal exposures to concentrations of atrazine and the chlorotriazine metabolites on lawns and golf courses after treatment with atrazine are anticipated for adults as they reenter lawns to do yard work, mow, walk, or play golf. Post application dermal exposures are anticipated for toddlers on treated lawns crawling, and playing. Incidental oral exposures are anticipated for toddlers as a result of hand-to-mouth activity, soil and turf ingestion (as well as granule ingestion) while playing on treated lawns. Inhalation exposures are not expected for adults or children reentering treated lawns and golf courses after treatment. Short-term dermal post application exposures are possible for adults, and short-term post application dermal and incidental oral exposures are possible for toddlers. Based on atrazine turf residue dissipation studies, intermediate-term residential post application exposures are not anticipated for either adults or children.

For the purposes of incorporating short-term dermal exposures into risk assessments, HIARC selected an endpoint of 6.25 mg/kg/day based on delayed puberty as described above. The oral NOAEL of 6.25 mg/kg/day was adjusted for dermal exposure by use of a dermal absorption factor ofsix percent from a human study to provide a dermal NOAEL of 104 mg/kg/day. For the purposes of incorporating short-term incidental oral exposures into risk assessments for toddlers, HIARC selected the same endpoint, delayed puberty based on a NOAEL of 6.25 mg/kg/day. This study was considered appropriate because the duration of exposure (30-days) matches the duration (up to 30 days) in the short-term dermal risk assessment, and the endpoint (delayed puberty in young males) represents a neuroendocrine effect consistent with the mode of action for atrazine. This endpoint is particularly relevant to assessing toddler exposures. Short-term post application dermal and incidental exposures can be combined because of the common toxic effect between the two pathways, i.e., both the short-term dermal and incidental oral endpoints are based on delayed puberty.

Dermal postapplication exposure estimates were conducted using the mean daily postapplication residue from each of the chemical specific turf transferable residue (TTR) studies (granular and dry flowable formulations) both before and after irrigation. Dermal transfer coefficients from the revised Residential SOPs were used. The SOPs use a high contact activity based on the use of Jazzercise to represent the exposures of an actively playing child. These assumptions are expected to better represent residential exposure and are still considered to be high-end, screening level assumptions.

A total of eight dermal postapplication exposure scenarios were evaluated. Two of these scenarios , both involving exposure following application of a liquid formulation, had short-term dermal MOEs less than 300, for high-contact activities on turf for the child (MOE = 110) and adult (MOE= 190). These exposure scenarios are only of concern when dermal contact is made with “wet turf.” However, HED cannot discount the possibility that turf may become wet after treatment. Exposure scenarios based on dermal contact with dry turf are not of concern. Residues had dissipated sufficiently by the 2nd day after treatment to raise MOEs for children to 750 and adults to 1300. For adults golfing and mowing on treated turf, all short-term dermal MOEs exceeded 300. Assuming <u>all</u> of the adult dermal exposures (golfing, mowing, high-contact activities) would happen in one day over eight hours, the aggregate dermal MOE ranges from 170 to 4,000, depending on the formulation applied to the turf. This very high-end aggregate risk estimate is driven by the single adult and child ‘high-contact activity on the day of application’ scenario of concern.

As there were no comparable data for spray-treated turf (because children’s hands may be wet and sticky and TTR data were obtained with dry wipe methods), the Residential SOPs were used to estimate incidental oral exposure for toddlers (young children) mouthing their fingers after touching spray-treated turf. Therefore, the risk estimate for mouthing spray-treated turf is based on the application rate of 2 lbs ai/acre, and SOP assumptions. The risk estimate (MOE) for mouthing hands after touching spray-treated turf was 210 while mouthing grass and soil ingestion had MOEs of 1100 and 62,000, respectively. The aggregation of all of these mouthing activities results in a MOE of 200. Incidental ingestion of atrazine granules was not aggregated with these other mouthing activities because it is considered episodic. However, all risk estimates based on a single granule ingestion were of concern with MOEs of 16 to 110 depending on the formulation.

It is considered reasonably likely that dermal and oral incidental exposures may occur in the same day for children playing on atrazine-treated lawn. However, both the short-term dermal (for the spray-treated turf) and short-term hand-to-mouth exposures have MOEs less than 1000. Aggregating the route-specific MOEs for playing on the sprayed turf and hand-to-mouth exposure results in an MOE of 71, which further exceeds the level of concern. Data from a hand press study of dermal transfer from turf treated with granular formulations of atrazine were used to estimate hand-to-mouth exposure for children on granular-treated turf. These risk estimates indicate risks of concern for each route until residues of atrazine have declined or dry after treatment.

A single label for atrazine 4L (EPA Reg. No. 829-268) permits professional application to “corn in the home garden.” As this was the only such label use found, the potential postapplication risk to residents was not quantitatively assessed; but as the potential risk estimated for postapplication workers was low, the residential risk is also considered low. Atrazine is usually applied when corn is 12" tall. Tables 10 and 11 summarize these results.

Table 10. Residential Short-Term Dermal Postapplication Risks for Atrazine (Using TTR values from liquid and granular Atrazine turf studies - MRID Nos. 449580-01, 449588-01)

Dermal Scenarios	Application Rate (lb ai/acre)	xposure Time (hours/day)	Short Term Risks				
			Transfer Coefficient[a] (cm^2/hr)	TTR[b] (ug/cm^2) DAT 0-1		MOEs [c]	
				GA - liquid	NC-liquid FL-granular	GA - liquid	NC-liquid FL- granular
Adult dermal turf contact liquid formulation	2	2	14,500	0.241	(NC) 1.32	1000 (dry turf)	(NC) 190 (wet turf)
Adult dermal turf contact granular formulation	2	2	14,500	0.0585	(FL) 0.216	4300	(FL) 1200
Child dermal turf contact liquid formulation	2	2	5,200	0.241	(NC) 1.32	620 (dry turf)	(NC) 110 (wet turf)
Child dermal turf contact granular formulation	2	2	5,200	0.0585	(FL) 0.216	2600	(FL) 690
Adult walking, playing golf liquid formulation	2	4	500	0.241	(NC) 1.32	15,000	(NC) 2800
Adult walking, playing golf granular formulation	2	4	500	0.0585	(FL) 0.216	62,000	(FL) 17,000
Adult push mowing lawn liquid formulation	2	2	500	0.241	(NC) 1.32	30,000	(NC) 5500
Adult push mowing lawn granular formulation	2	2	500	0.0585	(FL) 0.216	120,000	(FL) 34,000
Aggregate Daily Dermal Risk, Adult (All Activities Listed): Liquid Formulation[f]						1000	170
Aggregate Daily Dermal Risk, Adult (All Activities Listed): Granular Formulation[f]						4,000	1000

Footnotes:

[a]Transfer coefficient from proposed changes to the Residential SOP's (12/99).

[b]TTR Source: liquid and granular turf studies MRID # 449580-01, 449588-01, DAT 0-1 residue. The highest residue value occurring immediately following application to DAT 1 was used for determination of DAT 0-1 MOE's. The highest residue values were detected after liquid application of a 90 DF formulation. The 90 DF study was conducted using an application rate of 2 lb ai/acre.

[c]MOE = Short-term NOAEL (104 mg/kg/day; based on a dermal study)/dermal dose where dermal dose =TTR (µg/cm^2) ***X*** TC (cm^2/hr) x conversion factor (1 mg/1,000 µg) ***X*** exposure time (2 hrs/day)/body weight (70 kg adult or 15 kg one- to six-year-old).

[d]TTR source: liquid and granular turf studies MRIDs # 449580-01, 449588-01, DAT 7 residue.

[e]Aggregate MOE may be obtained by dividing NOAEL by sum of daily dermal doses, or by taking the inverse of the sum of the inverses of the MOEs:

$$\text{Aggregate MOE} = 1/[\ 1/\text{MOE}_1 + 1/\text{MOE}_2 \text{ etc.}]$$

Table 11. Residential Short-Term Oral Nondietary Postapplication Risks to Children (one to six years) from "Hand-to-Mouth" and Ingestion Exposure When Reentering Lawns Treated with Granular or Liquid Atrazine Formulations

Type of Exposure	Application Rate[a] (lb ai/acre)	Ingestion Rate or Other Assumptions[b]	Oral Dose[d] (mg/kg/day)	MOE[e]
Hand-to-Mouth Activity	2 liquid	20 cm^2/event surface area of one to three fingers; 20 events/hr; 5% of ai dislodgeable with potentially wet hands; 50% saliva extraction factor	0.030	210
	granular	Hand-press study	0.0066	950
Turfgrass/ Object-to-Mouth	2 liquid or granular	25 cm^2/day of turf; Corn DFR normalized to 2 lb ai/acre = 3.4 $\mu g/cm^2$	0.0019	3300
Ingestion of Soil	2 liquid or granular	100 mg/day ingestion; 0.67 cm^3/gm soil	1.0E-4	62,000
Aggregate of the Oral Exposures Above[f] (liquid formulations)			0.036	200
Aggregate of the Oral Exposures Above[f] (granular formulations)			0.0086	730
Ingestion of Granules	0.42% ai	0.2-0.4 g/day (100-200 lbs formulation /acre)	0.056-0.11	55 - 110
	1.5% ai		0.2-0.4	16 - 31

Footnotes:

[a]Application rates represent maximum label rates from current EPA registered labels.

[b]Assumptions from Draft Residential SOP's (1997, revised 2/01).

[c]TTR Source: liquid and granular atrazine turf studies MRID Nos. 449580-01; 449588-01. Short-term risks assessed using DAT 0-1 residue values.

[d]Oral doses calculated using formulas presented in the Residential SOPs (December, 1999). Short-term doses were calculated using the following formulas:

Hand-to-mouth

In the absence of DFR data, Revised Residential SOPs (02/01) are used:

oral dose to child (one-to six-year old) on the day of treatment (mg/kg/day) = [application rate (lb ai/acre) ***X*** fraction of residue dislodgeable with potentially wet hands (five percent) ***X*** 11.2 (conversion factor to convert lb ai/acre to $\mu g/cm^2$)] ***X*** median surface area for one to three fingers (20 cm^2/event) ***X*** hand-to-mouth rate (ST: 20 events/hour) x 50 percent saliva extraction factor x exp. time (2 hr/day) ***X*** 0.001 mg/µg]/bw (15 kg child).

` For granular formulations, the atrazine granular hand-press study data (MRIDs 45622310, 45622311) were used: the average moistened hand-mouth granular residue transfer rate of 1.1 percent of the ai application rate.

Grass/Object Mouthing

oral dose to child (one- to six-year-old) on the day of treatment (mg/kg/day) = [application rate (lb ai/acre ***X*** 11.2 (conversion factor to convert lb ai/acre to $\mu g/cm^2$)) ***X*** fraction of residue dislodgeable (5%) ***X*** ingestion rate of grass (25 cm^2/day) ***X*** 0.001 mg/µg] / bw (15 kg child).

Soil ingestion

oral dose to child (one- to six-year old) on the day of treatment (mg/kg/day) = [(application rate (lb ai/acre) ***X*** fraction of residue retained on uppermost 1 cm of soil (100% or 1.0/cm) ***X*** 4.54E+08 µg/lb conversion factor ***X*** 2.47E-08 acre/cm^2 conversion factor ***X*** 0.67 cm^3/g soil conversion factor) x 100 mg/day ingestion rate ***X*** 1.0E-06 g/µg conversion factor]/bw (15 kg).

Short term dose based residue on the soil on day of application.

Granular pellet ingestion

(mg/kg/day) oral dose to child (one- to six-year old) =
[Granule ingestion rate (0.2-0.4 g/day) ***X*** Fraction of ai of granule formulations ***X*** 1,000 mg/g]/bw (15 kg).

[e]Oral MOE = Oral NOAEL (6.25 mg/kg/day for short-term assessments)/Oral Dose (mg/kg/day). Oral NOAEL determined from a rat study. MOEs are reported to two significant figures; target MOE is at least 300.

[f]Combined MOE may be obtained by dividing oral NOAEL by sum of oral doses, or by taking the inverse of the sum of the inverses of the MOEs:

Combined MOE = $1/[\,1/MOE_1 + 1/MOE_2$ etc.]

a. Uncertainties and Data Gaps

These risk estimates are considered to be conservative. Residential handler exposure and risk estimates were conducted using two sets of surrogate chemical data: the ORETF study data and the Residential SOPs. Generally, the Residential SOP data (default assumptions) are more conservative than ORETF data. Both data sets show wide variations in exposure depending on individual behaviors. Dermal postapplication exposures to atrazine were based on the higher average daily residues from the chemical-specific TTR study data, but also used standard assumptions for transfer coefficients. Oral ingestion scenarios for liquid formulations are based on standard assumptions and formulae (Residential SOPs) which are designed to be screening level. Oral ingestion scenarios for hand-to-mouth exposures from granular formulations are based on a chemical-specific study designed to determine the residue and/or granules adhering to a wet hand after being repeatedly pressed onto turf treated with a granular formulation and are considered more refined. Granular ingestion is considered episodic in nature and therefore not aggregated.

4.4.3 Other (Spray Drift)

Spray drift is always a potential source of exposure to residents close to spraying operations. This is particularly the case with aerial application, but, to a lesser extent, could also be a potential source of exposure from groundboom application methods. The Agency has been working with the Spray Drift Task Force, EPA Regional Offices and State Lead Agencies for pesticide regulation and other parties to develop the best spray drift management practices. The Agency is now requiring interim mitigation measures for aerial applications that must be placed on product labels/labeling. The Agency has completed its evaluation of the new data base submitted by the Spray Drift Task Force, a membership of U.S. pesticide registrants, and is developing a policy on how to appropriately apply the data and the AgDRIFT computer model to its risk assessments for pesticides applied by air, orchard airblast and ground hydraulic methods. After the policy is in place, the Agency may impose further refinements in spray drift management practices to reduce off-target drift and risks associated with aerial as well as other application types where appropriate.

5.0 AGGREGATE RISK ASSESSMENTS AND RISK CHARACTERIZATION

Aggregate risk assessments have been conducted for acute, short-term, and intermediate-term and chronic exposures to atrazine and the chlorinated metabolites. The acute aggregate risk assessment combines exposures to atrazine and the chlorinated metabolites in food and drinking water. The short-term aggregate risk assessment combines exposures to atrazine and the chlorinated metabolites in food and drinking water with residential exposures to atrazine, *per se*, anticipated to occur between one and 30 days after use of atrazine products at home. The intermediate-term and chronic aggregate risk assessment combines exposures to atrazine and the chlorinated metabolites in food and drinking water, only, because intermediate-term (30 days to six months) and chronic (six months to lifetime) exposure scenarios for the registered recreational turf uses of atrazine are not expected.

The risk estimates for combined exposures to concentrations of atrazine and the chlorotriazine metabolites in food, drinking water, and through home uses presented in this document are deterministic and are based on the assumptions and “reciprocal ARI” method as described in HED SOP 99.5.[3] The reciprocal ARI method was necessary because of different uncertainty factors have been applied to dietary (1000x) and residential (300x) risk assessments.

5.1 Acute Aggregate Exposure and Risk Estimates

The aggregate risk assessment for acute exposures to atrazine and the chlorinated metabolites combines high-end one-day exposures through food and drinking water, only. HED does not anticipate high-end exposures through food, drinking water, and residential use all occurring on the same day. Therefore, acute aggregate risk estimates are the same as those presented for acute drinking water risks. Exposure to atrazine from food sources (based on refined exposure estimates) and drinking water (based on surface and groundwater monitoring data on finished drinking water) do not exceed HED’s level of concern for acute dietary risk for any relevant subgroup, as described previously under the section for drinking water risk estimates.

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[3] "Standard Operating Procedure (SOP) for Incorporating Estimates of Drinking Water Exposure into Aggregate Risk Assessments." HED, August 1, 1999.

5.2 Intermediate-Term and Chronic Aggregate Exposure and Risk Estimates

The aggregate risk assessment for intermediate-term and chronic exposures to atrazine and the chlorinated metabolites combines estimates of high-end seasonal or long-term average exposures, respectively, to atrazine through drinking water with long-term average exposures through food. Neither intermediate-term nor long-term (chronic) exposures are expected to occur in the home from residential uses of atrazine. Therefore, intermediate-term and chronic aggregate risk estimates are the same as those presented for intermediate-term and chronic drinking water risks.

Based on a screening-level assessment of 3,670 CWS approximately 33 percent of all CWS using surface water in the U.S., HED has concern for intermediate-term and chronic effects associated with annual and seasonal average exposures to combined residues of atrazine plus its chlorinated metabolites in drinking water from 29 CWS using surface water for infants. Several of these CWS had exposures of concern for children and adults (male and female). These 29 CWS had seasonal exposures greater than 100% of the cPAD at the 99.9^{th} percentile of exposure in one, two or at most three years during the period 1993 to 2001. These 29 CWS serving ~180,000 people represent variously 0.14 percent of all CWS monitoring for atrazine under the SDWA using either surface or groundwater or a blend, 0.59 percent of the 4,886 CWS using surface water, and 0.79 percent of the 3,670 CWS using surface water with data on concentrations of atrazine and the chlorotriazine metabolites.

In addition, 52 CWS using surface water are suspected of high-end exposures and warrant further monitoring.

Intermediate-term and chronic exposures in rural wells in atrazine use areas are also of concern. Aggregate intermediate-term and chronic exposures in CWS using groundwater are not of concern. See Section 4.3 for details.

5.3 Short-Term Aggregate Exposure and Risk Estimates

Short-term estimates of aggregate risk for adults applying atrazine products combine exposures through the dermal, dietary (food and drinking water), and inhalation routes. Short-term estimates of aggregate risk for post application exposures of adults combine dietary exposures (food and drinking water) and post application dermal exposures after lawn treatments. Short-term estimates of aggregate risk for post application exposures of toddlers combine dietary exposures (food and drinking water) with post application dermal and incidental oral exposures after lawn treatments. Short-term aggregate risk estimates inclusive of residential exposures are only applicable for those regions of the country where atrazine is used on turf grass, generally the Southeast and Florida.

For the purposes of aggregating short-term dermal, inhalation, and incidental oral exposures with oral dietary exposures (including food and drinking water), the HIARC selected endpoints for dermal (104 mg/kg/day based on 6.25 mg/kg/day modified by a six percent dermal absorption factor), inhalation (6.25 mg/kg/day), and incidental oral (6.25 mg/kg/day) exposures all based on delayed preputial separation in males (delayed puberty). The incidental oral endpoint has been used to incorporate dietary exposures to the chlorotriazines through food and drinking water into the aggregate risk assessment. Because the endpoint selected for each exposure pathway is based on the same effect (delayed puberty in young male rats), exposures across all these pathways can be aggregated.

The procedures outlined in HED SOP 99.5 have been used to estimate aggregate risk from short-term exposures to chlorotriazines. The theoretical upper limit in drinking water for short-term exposures is referred to as a short-term DWLOC. It is based on estimates of average exposure to chlorotriazines in food added to estimates exposure to high-end concentrations of atrazine, *per se*, during application or immediately after application of atrazine to lawns. Measured concentrations of concentrations of atrazine and the chlorotriazine metabolites in surface water and groundwater from monitoring data (as presented earlier in this document) were compared to the short-term DWLOCs calculated for adults and children. If the short-term DWLOC values are greater than the measured average concentrations for concentrations of atrazine and the chlorotriazine metabolites in surface water and groundwater, there is no concern for short-term aggregate exposures to concentrations of atrazine and the chlorotriazine metabolites through food, drinking water, and home uses.

5.3.1 Short-Term Aggregate Risk Estimates for Adult Handlers

HED's aggregate risk assessment combines dermal, inhalation and oral (dietary) exposures in the short-term for adults applying atrazine products to the lawn and garden. These exposures have a common toxic effect, delayed puberty as a biomarker for neuroendocrine effects. Five exposure scenarios were evaluated. Of the five scenarios, only applications of granular formulations of atrazine applied over 0.5 acres with a belly-grinder results in aggregate exposures that exceed HED's level of concern. Aggregate short-term DWLOC values are presented for the five adult handler scenarios in Table 12.

Measured high-end concentrations of atrazine and the chlorotriazine metabolites in finished drinking water reach a maximum weekly concentration of 89 ppb. As can be seen in Table 12, the calculated short-term DWLOC values based on the highest exposure scenario for adults is zero. All other short-term DWLOC values are greater than the measured maximum weekly concentrations of atrazine and the chlorotriazine metabolites in surface water and groundwater (89 ppb) and are not of concern. Therefore, short-term aggregate exposures of adult handlers to concentrations of atrazine and the chlorotriazine metabolites from the specified lawn treatments only exceed HED's level of concern for belly-grinder applications. All other exposure scenarios do not exceed HED's level of concern. Short-term DWLOC values for adult handlers are based on an average male and female body weight of 70 kg.

Table 12. Aggregate DWLOCs based on High-End Residential Handler Short-Term Exposures for Adults (Male and female) Making Applications @ 2 lbs ai/acre (Maximum) to Lawns

Exposure Scenario	Dietary Dose (mg/kg/day)	Dermal Dose (mg/kg/day)	Absorbed Dermal Dose (mg/kg/day)	Inhalation Dose (mg/kg/day)	Aggregate MOE (Dermal + Inhalation)	ST DWLOC (ppb)
Backpack Sprayer	0.000003	0.0034	0.0002	0.00002	28,000	219
Low Pressure Hand wand	0.000003	0.066	0.004	0.00002	1600	273
Hose-end Sprayer	0.000003	0.16	0.0096	0.00027	640	105
Granular with Push-type Spreader	0.000003	0.0097	0.0006	0.00001	11,000	159
Granular with a Belly-grinder	0.000003	0.072 - 1.6	0.004 -0.096	0.00004	65	zero

5.3.2 Short-Term Aggregate Risk Estimates for Toddlers' Post Application Exposures

Aggregate risk estimates for short-term exposures of toddlers playing on atrazine-treated lawns exceed HED's level of concern. HED's aggregate risk assessment for short-term exposures of toddlers playing on atrazine-treated lawns immediately after application is based on the results of the short-term post application incidental oral exposure and risk assessment for toddlers. Although dermal, inhalation, dietary, and incidental oral exposures could be combined for toddlers' post application exposures, HED notes that toddlers' exposures from individual and aggregated pathways for incidental oral exposures already exceed HED's levels of concern; i.e., a MOE of 200 for liquid formulations based on combined exposures from hand-to-mouth transfer of residues, grass and soil ingestion activities by toddlers. Toddlers' exposures from individual and aggregated pathways for incidental oral exposures based on granular formulations do not exceed HED's levels of concern; i.e., a MOE of 730. Exposure to atrazine through ingestion of granules by toddlers result in MOEs of 16 to 110. Toddlers' short-term dermal exposures also have MOEs less than 300 for liquid formulations under wet conditions. Therefore, any addition (or aggregation) of exposures through the dermal, inhalation or dietary (food and drinking water) pathways with the incidental oral exposures would result in risk estimates that further exceed HED's level of concern for toddlers. Because short-term dermal and incidental oral post application exposure scenarios exist, which separately result in MOEs less than 300, HED has not aggregated exposures across these routes for toddlers.

5.3.3 Short-Term Aggregate Risk Estimates for Adults' Post Application Exposures

Table 13 summarizes the results of HED's aggregate risk assessment for short-term exposures of adults playing on atrazine-treated lawns immediately after application. These estimates of risk combine dermal and oral (dietary) exposures because short-term dermal and dietary exposures have a common toxic effect, delayed puberty as a biomarker for neuroendocrine effects.

Table 13. Aggregate DWLOCs Based on High-End Residential Postapplication Short-Term Exposures for Adults on Treated Turf Grass

Type of Exposure	Formulation/ Application Rate (lbs ai/acre)	Dietary Dose* (mg/kg/day)	Dermal Dose (mg/kg/day)	Absorbed Dermal Dose (mg/kg/day)	Dermal MOE (mg/kg/day)	ST DWLOC* (ppb)
Dermal Contact	2 lb ai/acre (liquid/ wet turfgrass)	0.000003	0.55	0.033	190	zero
	2 lb ai/acre (liquid/ dry turfgrass)	0.000003	0.10	0.006	1000	150
	2 lb ai/acre (granular)	0.000003	0.09	0.0054	1200	157
Dermal Contact Walking/ Playing Golf	2 lb ai/acre (liquid)	0.000003	0.038	0.0023	2800	195
	2 lb ai/acre (granular)	0.000003	0.0062	0.0004	17,000	215
Dermal Contact Pushing lawn Mower	2 lb ai/acre (liquid)	0.000003	0.019	0.0011	5500	206
	2 lb ai/acre (granular)	0.000003	0.003	0.00018	34,000	217

The exposure scenario for adults engaged in high contact activities on lawns treated with liquid formulations of atrazine results in aggregate risk estimates exceeding HED’s level of concern if turf becomes wet or damp after application. The short-term DWLOC for this scenario is zero. Because weekly concentrations of atrazine and the chlorotriazine metabolites have been measured in drinking water up to 89 ppb, risk estimates for adults' short-term aggregate exposures under this scenario exceed HED’s level of concern. All other adult post application exposure scenarios result in short-term aggregate risk estimates that do not exceed HED’s level of concern. Table 13 shows short-term DWLOC values for adults that are greater than measured weekly concentrations chlorotriazines in drinking water for the exposure scenarios for playing golf, and mowing lawns. Aggregation of any of these activities with the high contact activity exposure scenario for adults playing on treated lawns would result in risk estimates that exceed HED’s level of concern. Short-term DWLOC values for adult post application exposures are based on an average body weight of 70 kg.

6.0 CUMULATIVE RISK

The Food Quality Protection Act (1996) stipulates that when determining the safety of a pesticide chemical, EPA shall base its assessment of the risk posed by the chemical on, among other things, available information concerning the cumulative effects to human health that may result from dietary, residential, or other nonoccupational exposure to other substances that have a common mechanism of toxicity. The reason for consideration of other substances is due to the possibility that low-level exposures to multiple chemical substances that cause a common toxic effect by a common mechanism could lead to the same adverse health effect as would a higher level of exposure to any of the other substances individually. A person exposed to a pesticide at a level that is considered safe may in fact experience harm if that person is also exposed to other substances that cause a common toxic effect by a mechanism common with that of the subject pesticide, even if the individual exposure levels to the other substances are also considered safe.

HED did not perform a cumulative risk assessment as part of this risk assessment for atrazine because the review to determine if there are any other chemical substances that have a mechanism of toxicity common with that of atrazine has just been completed. HED evaluated atrazine, simazine, and propazine for a mechanism of toxicity common to all three compounds and their degradates. For purposes of this tolerance reassessment review, EPA has provided an aggregate risk assessment for atrazine and its chlorinated metabolites only.

7.0 OCCUPATIONAL RISK ASSESSMENTS

HED has determined that there is the potential for short-term (one to 30 days) and intermediate-term (30 days to several months) dermal and inhalation exposures of mixers, loaders, and applicators handling atrazine during application associated with the registered uses of atrazine. HED has also determined that there is the potential for short-term and intermediate-term post application dermal exposures to atrazine from harvesting activities. Long-term (chronic) occupational exposures of several months to lifetime duration are not anticipated.

For the purpose of short-term occupational risk assessments, HIARC selected endpoints for dermal (104 mg/kg/day based on 6.25 mg/kg/day modified by a six percent dermal absorption factor), inhalation (6.25 mg/kg/day), and incidental oral (6.25 mg/kg/day) exposures all based on delayed preputial separation in males (delayed puberty). An absorption factor of 100 percent is applied for inhalation exposures. Because the short-term dermal and inhalation endpoints chosen for risk assessment are based on the same toxic effects, dermal and inhalation exposures can be aggregated.

For all intermediate-term exposures, a toxicity endpoint was selected based on attenuation of the pre-ovulatory LH surge in a subchronic study in an oral study of Sprague-Dawley rats with a NOAEL of 1.8 mg/kg/day. The dermal absorption factor of six percent was based on a human study in which 10 human volunteers were exposed to a single topical dose of atrazine. The same oral endpoint selected for intermediate-term dermal exposure (1.8 mg/kg/day) was used for intermediate-term inhalation exposure. Because the dermal and inhalation endpoints for intermediate-term exposure are based on the same toxic effect, they may be aggregated.

The target margin of exposure (MOE) of 100 or more for occupational exposure scenarios was selected based upon 10X uncertainty factor (UF) for intraspecies variation and 10X UF for interspecies extrapolation.

7.1 Occupational Handler

The Agency has determined that there are potential exposures to mixers, loaders, applicators, and other handlers during usual use-patterns associated with atrazine. Fifteen major exposure scenarios were identified for atrazine, including mixing, loading, and applying using aerial, ground spray, granular, fertilizer admixture, and lawn application methods. The major handler scenarios involved multiple crops and application rates, resulting in over 120 different exposure estimates. The largest agricultural use of atrazine, and the largest potentially exposed occupational population, involves the mixing, loading and application of atrazine to row crops. Most of the occupational exposure studies submitted by the registrant have measured exposure of these workers. Several studies monitored potential dermal and inhalation exposure to full time mixer/loaders and applicators in the corn belt. These studies used either passive dosimeters, urine biomonitoring, or both. All of the passive dosimetry studies reported residues in terms of the parent compound, atrazine, only. The biomonitoring studies measured urinary chlorotriazines and back-calculated atrazine dose based on a human excretion study.

The Agency also reviewed an agricultural handler study that included both passive dosimetry and biomonitoring of urinary metabolites of atrazine, and found the unit exposures were within one order of magnitude of the values in the Pesticide Handler Exposure Database (PHED) v. 1.1. The PHED is used by the Agency as a surrogate chemical database for handler exposure values. The passive dosimetry study was re-submitted by the registrant, in combination with the Agency's PHED values for ground applicators using enclosed systems. This was included as part of the risk estimates and compared to PHED-based estimates for agricultural handlers using closed systems, with reasonable agreement. Another study using biomonitoring to determine worker exposure included over 100 replicates, but did not meet adequate quality control criteria to allow the results to be related the quantity of atrazine handled. Instead, the range of daily dose per "typical" agricultural handler of atrazine in various formulations, using a variety of protective gear and application systems, confirms the findings of the other biomonitoring study and supports the overall agricultural handler risk assessment based on passive dosimetry.

The Outdoor Residential Exposure Task Force (ORETF) also submitted exposure studies to the Agency for either occupational or non-occupational residential applicator exposure. Those studies include application of granular formulations by push-spreader, professional lawn care operators using truck-mounted hoses with hand-gun controlled spray, resident-applicator using a granular push spreader, and resident-applicator using a hose-end spray.

The Agency estimated exposure to commercial handlers engaged in impregnating atrazine onto dry bulk fertilizer using dermal and inhalation unit exposure data from the PHED scenario for mixing/loading liquids using a closed system. However, such an exposure surrogate is less appropriate for transferring the treated dry bulk fertilizer from the auger truck to the application equipment. There are no data or reasonable surrogate available for this operation.

7.1.1 Estimates of Handler Risk

The risk estimates presented consider exposures at baseline, i.e., a single-layer of clothing, shoes, socks, and bare hands; exposures with additional protective equipment (PPE) consisting of chemical-resistant gloves, coveralls, and respirators; and exposures with engineering controls, where closed mixing/loading and application equipment are used. For the detailed calculations of exposure and risk estimates, see Attachment VI.

7.1.2 Short-Term Exposures (one to 30 days)

For short-term exposure estimates based on either PHED data, chemical specific exposure studies, and/or ORETF data, with appropriate PPE or engineering controls, all but one short-term aggregate (dermal and inhalation) handler exposure scenario had MOEs greater than 100, and thus, do not exceed HED's level of concern. The dry fertilizer admixture (mixer/loader) scenario exceeds the level of concern for the highest estimated daily quantities handled. However, there is considerable uncertainty in this scenario due to a lack of data on fertilizer mixing, and the use of grain treatment as a surrogate. There were no exposure data for liquid/liquid fertilizer treatment, so risk estimates for this scenario could not be calculated.

Based solely on PHED data, and after consideration of PPE or engineering controls, all but one short-term aggregate (dermal and inhalation) exposure scenario had MOEs greater than 100. The scenario of concern had a MOE of 64 for admixture of liquid atrazine formulation into bulk fertilizer. This estimate was based on exposure data from treating grain using closed commercial systems, but used a high-end estimate of quantity treated per day (960 tons). Engineering control methods were only required to mitigate exposure for five scenarios, where PPE were insufficient for mixer/loaders of liquids or dry flowable formulations for high-acreage aerial applications (i.e., 1200 acres/day).

The chemical specific passive dosimetry and biomonitoring studies support the PHED assessment. In these studies, the handlers monitored for the most part used closed mixing and loading systems and enclosed cab sprayers (that is, they incorporate a mixture of PPE and engineering controls). When the combined passive dosimetry/biomontoring handler study data were combined with PHED data for the ground application methods, all of the MOEs were greater than 100 (range 170-22,000). Only the liquid and dry fertilizer admixture scenario had MOEs less than 100 in the short-term, and this is a low confidence estimate due to a lack of specific handler information.

Biomonitoring study data alone were used to characterize the overall handler risk assessment, as the biomonitoring doses were highly variable and the activities, clothing, equipment, and quantities of atrazine handled varied with each individual. Therefore, the geometric mean of the maximum daily doses was determined from the urine biomonitoring, and compared to the atrazine short and intermediate term endpoints. The 90^{th} percentile of the maximum internal doses was also compared to the short-term endpoint for each general handler category. These MOEs are compared to the passive dosimetry results in Table 3 of the Occupational and Residential Exposure Assessment (Attachment VI). The MOEs determined from the actual internal doses are all greater than 100, probably because the quantities handled per day averaged less than the 400 lbs ai used to estimate high-acreage ground application scenarios. Applicators generally handled about one-half as much atrazine per day as the mixer/loaders. Therefore, the MOEs estimated by using standard acreage (200) and maximum application rate (2 lbs/acre) range from 37 to 114 for 90^{th} percentile passive dosimetry and from 64 to 250 for 90^{th} percentile of biomonitoring.

Using the ORETF study data, where applicable, baseline short-term MOEs for lawn care operators (LCOs) spraying lawns or applying granular formulations were all greater than 100. Where PHED data were used, all LCO scenarios had MOEs greater than 100 with the use of gloves. Table 14 shows the estimated short-term exposures and risks for handlers for the specific scenarios assessed.

7.1.3 Intermediate-Term Exposures (30 days to several months)

For intermediate-term exposure estimates based on either PHED data, chemical specific exposure studies, or a combination of these data, with appropriate personal protective equipment (PPE) or engineering controls, most intermediate-term aggregate (dermal and inhalation) handler exposure scenarios had MOEs greater than 100, and thus, do not exceed HED's level of concern. There were no exposure data for liquid/liquid fertilizer treatment, so risk estimates for this scenario could not be calculated.

Using PHED data only, 77 of 100 (77 percent) of scenarios using additional PPE and 92/100 (92 percent) of scenarios for which engineering controls were feasible for handlers had intermediate-term aggregate (dermal and inhalation) MOEs greater than 100. There were no data for liquid/liquid fertilizer treatment and the right-of-way and hand sprays had no known engineering controls. Only the right-of-way scenario had a MOE less than 100 (37) with added PPE but had no known engineering exposure control method.

Using the corn applicator study/PHED combined data, with engineering controls, all applicable handler scenarios had MOEs greater than 100. Using the passive dosimetry study data alone, which reflected the use of engineering controls, the geometric means of the estimated doses result in handler MOEs of 210-610. Biomonitoring study data for handlers using mostly engineering controls provided estimated MOEs of 82 to 1600 using the geometric mean maximum dose for each task. Using the ORETF study data, all baseline clothing intermediate-term lawn care operator (LCO) handler scenarios had MOEs greater than 100. Where PHED data was used, LCO handlers required gloves to achieve MOEs greater than 100.

Intermediate-term exposures that exceed HED's level of concern are generally associated with mixing and loading of the largest quantities (liquid or dry flowable/WDG) of atrazine. Examples include the higher application rates and acreage for use on chemical fallow lands, grasslands, corn, sorghum, and in fertilizer admixture. With engineering controls, all applicator risk estimates have MOEs above 100. However, there were no data for engineering controls for the right-of-way sprayer scenario, which had an MOE of 37 with PPE. Table 14 shows the estimated intermediate-term exposures and risks for handlers for the specific scenarios assessed. The reader is referred to Attachment VI for details.

For detailed inputs (PHED and ORETF unit exposures, study data, and dose estimates) see Occupational and Residential Exposure Assessment (Attachment VI).

Table 14. Summary of Occupational Short-Term and Intermediate-Term Combined Dermal + Inhalation Handler Risks from Atrazine (Using PHED, ORETF, and Combined PHED/Handler Study Data)

Exposure Scenario	Crop Type	App. Rate (lb ai or lb ai/gallon & lbs fertilizer) (a)	Area Treated per Day (Acres or Gallons) (b)	Baseline		PPE (Gloves, Coveralls, Respirator)		Engineering Controls: PHED Data	Engineering Controls: PHED + Handler Study Data (c)	Engineering Controls: PHED Data	Engineering Controls: PHED + Handler Study Data (c)
				Short -term (d)	Intermediate-term (e)	Short-term (d)	Intermediate-term (e)	Short-term (d)		Intermediate-term (e)	
Mixer/Loader											
Mixing, Loading Liquid Formulations for Aerial Application (1a)	conifer forests, sugarcane, conifer (Christmas tree) farms, sod farms in FL	4	350	2	0.4	248	61	520	430	130	110
	sugarcane	2.6	350	3	0.7	381	94	800	660	200	160
	chemical fallow	1.4	1200	1	0.2	96	24	200	170	50	41
			350	2	0.6	330	82	690	570	170	140
			1200	1	0.4	206	51	430	360	110	88
			350	5	1.3	708	170	1500	1200	370	300
	CRP/grasslands	2	1200	1	0.3	144	36	300	250	75	62
			350	4	0.9	495	120	1000	850	260	210
	corn, sorghum	2	1200	1	0.3	144	36	300	250	75	62
			350	4	0.9	495	120	1000	850	260	210
		1	1200	2	0.5	289	71	610	500	150	120
			350	7	2	991	240	2100	1700	520	420
	sod farms	2	350	4	1	495	120	1000	850	260	210
Mixing/ Loading Liquid Formulations for Groundboom Application (1b)	sugar cane, macadamia nuts, guava, conifers, sod farms in FL	4	80	8	2	1084	270	2300	1900	560	460
	sugarcane	2.6	80	12	3	1667	410	3500	2900	870	710
	chemical fallow	3	450	2	0.5	257	63	540	440	130	110
			200	4	1	578	140	1200	1000	300	250
		1.4	450	4	1	550	140	1200	950	290	230
			200	9	2	1238	310	2600	2100	640	530
	CRP/grasslands	2	450	3	1	385	95	810	660	200	160
			200	6	2	867	210	1800	1500	450	370
	corn, sorghum	2	450	3	1	385	95	810	660	200	160
			200	6	2	867	210	1800	1500	450	370
		1	450	6	1	771	190	1600	1300	400	330
			200	12	3	1734	430	3600	3000	900	740
	roadsides	1	40	62	15	8669	2100	18000	15000	4500	3700
	bermuda grass rights of way	4	40	16	4	2167	540	4600	3700	1100	920
	golf course turf	2	40	31	8	4335	1100	9100	7500	2300	1800
	sod farms	2	80	16	4	2167	540	4600	3700	1100	920

Table 14. Summary of Occupational Short-Term and Intermediate-Term Combined Dermal + Inhalation Handler Risks from Atrazine (Using PHED, ORETF, and Combined PHED/Handler Study Data)

Exposure Scenario	Crop Type	App. Rate (lb ai or lb ai/gallon & lbs fertilizer) (a)	Area Treated per Day (Acres or Gallons) (b)	Baseline		PPE (Gloves, Coveralls, Respirator)		Engineering Controls: PHED Data	Engineering Controls: PHED + Handler Study Data (c)	Engineering Controls: PHED Data	Engineering Controls: PHED + Handler Study Data (c)
				Short -term (d)	Intermediate-term (e)	Short-term (d)	Intermediate-term (e)	Short-term (d)		Intermediate-term (e)	
Mixing/Loading Liquid Formulations for Rights-of-Way Sprayer (1c)	roadsides	1	40	62	15	8669	2100	18000	15000	4500	3700
	bermuda grass rights of way	4	40	16	4	2167	540	4600	3700	1100	920
Mixing/Loading Liquid Formulations for Lawn Handgun Application (LCO) (1d)	lawns, golf courses	2	100	12	3	1734	430	3600	3000	900	740
Mixing/Loading/ Incorporating Liquid Formulations onto Liquid or Dry Bulk Fertilizer (1e)	commercial fertilizer for corn, sorghum: *PHED data	2	960 tons	See Engineering Controls				64		19	
			500 tons	See Engineering Controls				120		36	
	*Helix study data		500 tons	See Engineering Controls				170		67	
	commercial fertilizer for corn, sorghum: *PHED data	1	960 tons	See Engineering Controls				120		38	
			500 tons	See Engineering Controls				230		72	
	*Helix study data		500 tons	See Engineering Controls				350		13	
	on-farm fertilizer for corn, sorghum	2	160	8	NA	700	NA	1900	NA	36	NA
		1	160	15	NA	1400	NA	3800	NA	67	150
Mixing/Loading Dry Flowable (Water Dispersible Granule) for Aerial (2a)	conifer forests, sugarcane, conifer (Christmas tree) farms, turf for sod in FL	4	350	66	16	105	26	380		130	
	sugarcane	2.6	350	100	25	161	40	580		140	
	chemical fallow	3	1200	26	6	41	10	150		36	
			350	88	22	140	35	500		120	
		1.4	1200	55	14	87	22	320		78	
			350	190	47	300	74	1100		270	
	CRP/grasslands	2	1200	38	10	61	15	220		54	
			350	130	33	210	52	750		190	
	corn, sorghum	2	1200	38	10	61	15	220		54	
			350	130	33	210	52	750		190	
		1	1200	77	19	122	30	440		110	
			350	260	65	420	100	1500		370	
	sod farms	2	350	130	33	210	52	750		190	
Mixing/	sugar cane, macadamia nuts, guava, conifers, sod farms in FL	4	80	290	71	459	110	1600		410	

Table 14. Summary of Occupational Short-Term and Intermediate-Term Combined Dermal + Inhalation Handler Risks from Atrazine (Using PHED, ORETF, and Combined PHED/Handler Study Data)

Exposure Scenario	Crop Type	App. Rate (lb ai or lb ai/gallon & lbs fertilizer) (a)	Area Treated per Day (Acres or Gallons) (b)	Baseline		PPE (Gloves, Coveralls, Respirator)		Engineering Controls: PHED Data	Engineering Controls: PHED + Handler Study Data (c)	Engineering Controls: PHED Data	Engineering Controls: PHED + Handler Study Data (c)
				Short -term (d)	Intermediate-term (e)	Short-term (d)	Intermediate-term (e)	Short-term (d)		Intermediate-term (e)	
Loading Dry Flowables (water dispersible) for Groundboom Application (2b)	sugarcane, macadamia nuts, guava, conifers, sod farms in FL	4	80	290	71	459	110	1600		410	
	sugar cane	2.6	80	440	110	706	170	2500		630	
	chemical fallow	3	450	68	17	109	27	400		97	
			200	150	38	245	61	880		220	
		1.4	450	150	36	233	58	840		210	
			200	330	82	525	130	1900		470	
	CRP/grasslands	2	450	100	25	163	40	580		140	
			200	230	57	367	91	1300		330	
	corn, sorghum	2	450	100	25	163	40	580		140	
			200	230	57	367	91	1300		330	
		1	450	210	51	326	81	1200		290	
			200	460	110	734	180	2600		650	
	roadsides	1	40	2300	570	3672	910	13000		3300	
		4	40	580	140	918	230	3300		820	
	golf course turf	2	40	1200	290	1836	450	6600		1600	
	sod farms	2	80	580	140	918	230	3300		820	
Mixing/Loading Dry Flowables (water dispersible) for Rights of Way (2c)	roadsides	1	40	2300	570	3672	910	13000		3300	
		4	40	580	140	918	230	3300		820	
Loading Granular Formulations (3)	sod farms	2	80	1200	310	5023	1200	62000		15000	
	golf course turf	2	40	2500	610	10047	2500	120000		31000	
Applicator											
Applying Liquids with Aircraft (4)	conifer forests, sugarcane, conifer (Christmas tree) farms, sod farms in FL	4	350	See Engineering Controls		See Engineering Controls		850		210	
	sugarcane	2.6	350					1300		320	
	chemical fallow	3	1200					330		82	
			350					1100		280	
		1.4	1200					710		170	
			350					2400		600	
	CRP/grasslands	2	1200					500		120	
			350					1700		420	
	corn, sorghum	2	1200	See Engineering Controls		See Engineering Controls		500		120	
			350					1700		420	
		1	1200					990		240	
			350					3400		840	
	sod farms	2	350					1700		420	

Table 14. Summary of Occupational Short-Term and Intermediate-Term Combined Dermal + Inhalation Handler Risks from Atrazine (Using PHED, ORETF, and Combined PHED/Handler Study Data)

Exposure Scenario	Crop Type	App. Rate (lb ai or lb ai/gallon & lbs fertilizer) (a)	Area Treated per Day (Acres or Gallons) (b)	Baseline		PPE (Gloves, Coveralls, Respirator)		Engineering Controls: PHED Data	Engineering Controls: PHED + Handler Study Data (c)	Engineering Controls: PHED Data	Engineering Controls: PHED + Handler Study Data (c)
				Short -term (d)	Intermediate-term (e)	Short-term (d)	Intermediate-term (e)	Short-term (d)		Intermediate-term (e)	
Applying Liquids for Groundboom Application (5)	sugar cane, macadamia nuts, guava, conifers, sod farms in FL	4	80	860	210	1690	420	4000	2700	980	620
	sugarcane	2.6	80	1300	330	2600	640	6100	4100	1500	950
	chemical fallow	3	450	200	51	401	99	940	640	230	150
			200	460	110	901	220	2100	1400	520	330
		1	450	440	110	858	210	2000	1400	500	310
			200	990	240	1931	480	4500	3100	1100	710
	CRP/grasslands	2	450	310	76	601	150	1400	950	350	220
			200	690	170	1352	330	3200	2100	790	500
	corn, sorghum	2	450	310	76	601	150	1400	950	350	220
			200	690	170	1352	330	3200	2100	790	500
		1	450	610	150	1202	300	2800	1900	700	440
			200	1400	340	2704	670	6400	4300	1600	990
	roadsides	4	40	1700	430	3380	840	8000	5000	2000	1200
		1	40	6900	1700	13519	3300	32000	20000	7900	5000
	golf course turf	2	40	3500	850	6759	1700	16000	10000	3900	2500
	sod farms, conifer (Christmas tree) farms	2	80	1700	430	3380	840	8000	5000	2000	1200
Applying Liquids with a Rights-of-Way Sprayer (6)	roadsides	4	40	33	8	150	37				
		1	40	130	33	601	150				
Applying Liquids with a Handgun (7) (ORETF)	lawns, golf courses	2	5	ND	ND	980 (G)	240 (G)				
Applying Impregnated Dry Bulk Granular Fertilizer with Tractor Drawn Spreader(8)	corn, sorghum	2	320	190	NA	660	NA	1000	NA	NA	NA
			160	380	NA	1300		1900			
		1	320	380	NA	1300		1900			
			160	900	NA	2600		4000			
Applying Granular with a Tractor Drawn Spreader (9)	corn, sorghum	2	200	610	150	2221	550	3200		790	
			80	1500	380	5553	1400	7900		2000	
		1	200	1200	300	4442	1100	6400		1600	
			80	3000	750	11106	2700	16000		4000	
	golf course turf	2	40	3000	750	11106	2700	16000		4000	

Table 14. Summary of Occupational Short-Term and Intermediate-Term Combined Dermal + Inhalation Handler Risks from Atrazine (Using PHED, ORETF, and Combined PHED/Handler Study Data)

Exposure Scenario	Crop Type	App. Rate (lb ai or lb ai/gallon & lbs fertilizer) (a)	Area Treated per Day (Acres or Gallons) (b)	Baseline		PPE (Gloves, Coveralls, Respirator)		Engineering Controls: PHED Data	Engineering Controls: PHED + Handler Study Data (c)	Engineering Controls: PHED Data	Engineering Controls: PHED + Handler Study Data (c)
				Short -term (d)	Intermediate-term (e)	Short-term (d)	Intermediate-term (e)	Short-term (d)		Intermediate-term (e)	
Mixer/Loader/Applicator											
Backpack Sprayer (PCO) (10)	lawns, golf courses	2	5	ND	ND	428	110	Not Feasible			
Low Pressure Handwand - Liquid Formulations (PCO) (11)	lawns, golf courses	2	5	7	2	1550	380	Not Feasible			
Lawn Handgun (PCO) [ORETF] (12a)Liquid	lawns, golf courses	2	5	ND	ND	1400 (G)	340 (G)	Not Feasible			
12b) WDG				ND	ND	1100 (G)	290 (G)				
12c) WSP				ND	ND	920 (G)	230 (G)				
Granulars with a Push Type Spreader (PCO) [ORETF] (13)	lawns, golf courses	2	5	1500	380	2100 (G)	520 (G)	Not Feasible			
Granulars with a Belly-grinder (PCO) (14)	lawns, golf courses	2	1	330	82	620	150	Not Feasible			
Flagging											
Flagging Sprays (15)	conifer forests, sugarcane, conifer (Christmas tree) farms, sod farms	4	350	310	76	466	120	910	NA	220	NA
	sugarcane	2.6	350	480	120	717	180	1400		350	
	chemical fallow	3	350	410	100	621	150	1200		300	
		1.4	350	880	220	1331	330	2600		640	
	CRP/grasslands	2	350	620	150	931	230	1800		450	
	corn, sorghum	2	350	620	150	931	230	1800		450	
		1	350	1200	310	1863	460	3600		900	
	sod farms	2	350	620	150	931	230	1800		450	

For detailed inputs (PHED and ORETF unit exposures, study data, and dose estimates) see Occupational and Residential Exposure Assessment (Attachment X)

Footnotes:

[a]Application rates represent maximum rates determined from EPA registered labels for atrazine. Typical use rates as determined by BEAD were assessed for corn and sorghum (1.0 lb ai/acre), sugarcane (2.6 lb ai/acre) and chemical fallow (1.4 lb ai/acre).

\` For commercial bulk fertilizer admixture: If two pounds atrazine active ingredient per acre is impregnated onto 400 pounds of fertilizer (for the 400 pounds fertilizer per acre rate), each ton (2000 pounds) of fertilizer would require 10 pounds of atrazine active ingredient. Thus, the total amount of active ingredient for 960 tons for the two pound active ingredient per 400 pounds of fertilizer per acre rate is (960)(10) = 9600 pounds of atrazine active ingredient handled per day. Using the registrant-supplied upper limit of production, only 500 tons are produced, so (500)(10) = 5000 pounds of atrazine handled per day. PHED data used for closed system liquid admixture. Arithmetic mean of operator exposure data from Helix™ Canadian seed treatment study submitted by Syngenta.

Application: 320 A/day estimated for 20-ton commercial truck spreader; 160 A/day reasonable max for 10-ton truck or on-farm equipment.

[b]Acres treated per day based on Exposure SAC Policy #9 “Standard Values for Daily Acres Treated In Agriculture,” Revised June 23, 2000.

[c]Engineering control dermal unit exposure values taken from submitted by Novartis Crop Protection Inc., passive dosimetry data combined with PHED corresponding scenario data.

[d]Engineering control inhalation unit exposure values from PHED Surrogate Exposure Guide - Draft August 1998 represent use of a dust/mist respirator (80 percent protection factor over baseline).

[d]Short-term dermal MOE = NOAEL (104 mg/-kg/day) /- daily dose (mg/-kg/-day).

Dermal daily dose (mg/-kg/-day)=daily unit exposure (mg/-lb ai) ***X*** application rate (lb ai/-acre) ***X*** amount handled per day (acres/day)/body weight (70 kg adult for short-term and 60 kg adult female–for developmental effects–for intermediate-term assessment). For intermediate-term dermal dose an absorption factor of six percent applies.

Short-term inhalation MOE = NOAEL (6.25 mg/kg/-day)/daily dose (mg/kg/day).

Inhalation daily dose (mg/kg/day) = inhalation unit exposure (Fg/lb Ai) ***X*** application rate (lb ai/acre) ***X*** amount handled per day (acres/day) ***X*** conversion factor (1 mg/1,000 Fg)/body weight (70 kg adult for short term and 60 kg developmental female for intermediate-term assessment).

[e]Intermediate-term dermal and inhalation MOE = NOAEL (1.8 mg/kg/day based on an oral developmental study)/daily dose (mg/kg/day).

CRP = Conservation Reserve Program

UNK = Unknown–additional use information needed

NN = Not needed–MOE > 100 at previous risk mitigation level

NF = Not feasible–no engineering control known for this application method

7.2 Occupational Postapplication

7.2.1 Estimates of Postapplication Risk

a. Short-Term and Intermediate-Term Exposures

Most of the atrazine used in agriculture is applied to corn and sorghum early in the season, either before weeds emerge (pre-emergence) or when the crops are quite small (generally less than 12 inches high). This fact, and the degree of mechanization in cultivating these crops, minimizes the post application contact of workers with the chemical on these crops. Nut and guava orchards are typically sprayed by ground equipment in such a manner as to limit the amount of foliage on the tree that is sprayed, although aerial application is also possible. There should be minimal postapplication exposure to workers in those types of orchards when ground methods are used. Mowing would be a common postapplication activity after either spraying method. Treated turf or grasses will routinely require reentry activities, such as mowing and watering, and eventually harvesting in the case of sod farms. Sod is typically treated with atrazine after harvest (i.e., the ground from which the turf is harvested is treated). Fallow, right-of-way, and prairie might also be mowed.

Three chemical-specific studies, one of dislodgeable foliar residue on corn, and two of transferable turf residues (TTR), were submitted to the Agency for consideration. All three were reviewed and found to acceptable for use in the atrazine risk assessment. Wherever possible, transfer coefficients (Tc) used in exposure calculations were based upon data submitted by the Agricultural Reentry Task Force (ARTF).

Using the average daily foliar residues from each study at day 0-1 and the average 30-day residue after treatment, all but one of the post application short- and intermediate-term dermal risk estimates were below the HED's level of concern (range 68 to 1.4 million). The lowest MOE (68) was for scouting sugar cane, using the corn DFR data. As with corn, use of atrazine on sugar cane is early season, prior to the filling in by the mature plants that crowds out weeds. Therefore the MOE for sugar cane is considered reasonable to high-end for early season scouting. Note that the highest day of application residue from atrazine sprayed turf, sampled while wet, resulted in an MOE of 40, but dry turf transferable residues on the same day did not equate to a risk of concern (MOE = 250). Postapplication risk estimates given as MOEs are provided in Tables 17, 18, and 19 for harvesting activities, granular formulations applied to turf and nut crops, and liquid formulations applied to turf and nut crops, respectively. The reader is referred to Attachment VI for details.

Table 17. Occupational Short- and Intermediate-Term Postapplication Risks for Atrazine

(Using DFR values from Atrazine Corn study MRID No. 448836-01)

Crop/Use Pattern	Application Rate (lb ai/acre)	Postapplication Activity	Transfer Coefficient[a]	Short Term Risks		Intermediate Term Risks	
				DFR[b] ($\mu g/cm^2$) (DAT 0-1)	MOE[c]	DFR[d] (ug/cm^2) (DAT 0-31)	MOE[e]
Corn	2	Scout (minimum foliage)	400	3.37	660	0.00158	3.5 e+05
		Irrigate, weed (minimum foliage)	100	3.37	2,700	0.00158	1.4 e+06
Conifer Forests	4	Scout (cruise, etc.)	1,000	6.74	140	0.0032	7.1 e+04
Sugarcane	4	Scout (full foliage)	2,000	6.74	68	0.0032	35,000
Sorghum	2	Scout, irrigate (minimum foliage)	100	3.37	2,700	0.00158	1.4 e+06

Footnotes:

[a]Transfer coefficient from Science Advisory Council for Exposure: Policy Memo # 003.1 "Agricultural Transfer Coefficients," Revised - August 7, 2000.

[b]DFR Source: corn study MRID # 448836-01, DAT 0-1 residue unless an MOE of >100 was not reached. In such cases risks were assessed on days following application until an MOE of 100 was determined. The highest residue value occurring between DAT 0-1 was used for determination of DAT 1 MOE's. The highest residue values were detected after application of a 90 DF wettable powder formulation. The study was conducted using an application rate of 2.5 lb ai/acre. The residues were first normalized to reflect an application rate of 2.0 lb ai/acre to aid in determination of highest residues (i.e., the 90 DF vs 4L formulations). When assessing activities involving a different application rate than was used in the study, the DFR values were adjusted proportionately to reflect the different application rates. For example, for sugarcane, which has a maximum label rate of 4.0 lb ai/acre, adjusted DFR = $\frac{\text{Corn DFR x 4 lb ai/A for sugarcane}}{\text{2 lb ai/A for corn}}$

[c]MOE = Short-term NOAEL (104 mg/kg/day; based on a dermal study)/dermal dose where dose = DFR (µg/cm^2) ***X*** TC (cm^2/hr) x conversion factor (1 mg/1,000 µg) ***X*** exposure time (8 hrs/day)/body weight (70 kg adult).

[d]DFR Source: corn study MRID # 448836-01, geometric mean of predicted residues DAT 0-31. See footnote b for further explanation.

[e] MOE = Intermediate-term NOAEL (1.8 mg/kg/day; based on an oral developmental study)/absorbed dermal dose where absorbed dose = DFR (µg/cm^2) ***X*** TC (cm^2/hr) ***X*** conversion factor (1 mg/1,000 µg) ***X*** exposure time (8 hrs/day) ***X*** dermal absorption (6%)/body weight (60 kg developmental female).

Note: DFR = Dislodgeable Foliar Residue

Table 18. Occupational Short- and Intermediate-Term Postapplication Risks for Granular Atrazine Formulations

(Using TTR values from granular Atrazine turf study MRID No. 449588-01)

Crop/ Use Pattern	Application Rate (lb ai/acre)	Postapplication Activity	Transfer Coefficient	Short-Term Risk Estimates				Intermediate-term Risk Estimates			
				TTR[b] (ug/cm^2) (DAT 0-1)		MOE[c]		TTR[d] (ug/cm^2) (DAT 0-31)		MOE[e]	
				FL (Nonirrig)	FL (Irrig)	FL (Nonirrig)	FL (Irrig)	FL (Nonirrig)	FL (Irrig)	FL (Nonirrig)	FL (Irrig)
Golf Course Turf	2	Mow, seed, scout, mechanical weed, aerate, fertilize, prune	500	0.216	0.0744	8,400	25,000	0.0211	0.0023	6,100	55,000
		Transplant, high contact	16,500	0.216	0.0744	250	750	NA	NA	NA	NA
Sod Farms (FL)	4	Mow, scout, mechanical weed, irrigate	500	NA				0.0422	0.0047	3,200	28,000
Sod Farms	2	Mow, scout, mechanical weed, irrigate	500	NA				0.0211	0.0023	6,100	55,000
Macadamia Nuts/Guava	4	Mow, scout, irrigate (turf under the trees)	500	0.432	0.15	4300	12,000	0.0422	0.0047	3,200	28,000

Footnotes:

[a]Transfer coefficient from Science Advisory Council for Exposure: Policy Memo # 003 .1 “Agricultural Transfer Coefficients,” Revised - August 7, 2000.

[b]TTR Source: granular atrazine to turf study MRID # 449588-01, DAT 0-1 residue. The highest residue value occurring between DAT 0-1 was used for determination of DAT 1 MOE’s. The study was conducted in GA and FL using an application rate of 2.0 lb ai/acre. Average daily TTRs were higher at the FL site and those residues were used for the exposure estimates shown. When assessing activities involving a different application rate than was used in the study, the TTR values were adjusted proportionately to reflect the different application rates. For example, for turf on Florida muck, which has a maximum label rate of 4.0 lb ai/acre, adjusted TTR = $\frac{\text{Turf TTR x 4 lb ai/A for Florida muck}}{\text{2 lb ai/A for turf}}$

[c]MOE = Short-term NOAEL (104 mg/kg/day; based on a dermal study)/dermal dose where absorbed dose = TTR (µg/cm^2) ***X*** TC (cm^2/hr) ***X*** conversion factor (1 mg/1,000 µg) ***X*** exposure time (8hrs/day)/ body weight (70 kg; adult).

[d]TTR Source: granular atrazine turf study MRID # 449580-01, geometric mean of actual residue data DAT 0-35. See footnote b for further explanation.

[e]MOE = Intermediate-term NOAEL (1.8 mg/kg/day; based on an oral developmental study)/absorbed dermal dose where absorbed dose = TTR (µg/cm^2) ***X*** TC (cm^2/hr) ***X*** conversion factor (1 mg/1,000 µg) ***X*** exposure time (8 hrs/day) ***X*** dermal absorption (6%)/body weight (60 kg; developmental female).

NA = Not applicable to this scenario based on typical application and postapplication activities.

TTR - Turf Transferable Residue

Table 19. Occupational Short- and Intermediate-Term Postapplication Risks for Liquid Atrazine Formulations Applied to Turf

(Using TTR values from liquid Atrazine turf study MRID No. 449580-01)

Crop/Use Pattern	Application Rate (lb ai/acre)	Postapplication Activity	Transfer Coefficient[a] (TC)	Short Term Risks				Intermediate Term Risks			
				TTR[b] (ug/cm^2) (DAT 0-1)		MOE[c]		TTR[d] (ug/cm^2) (DAT 0-31)		MOE[e]	
				GA	NC	GA	NC	GA	NC	GA	NC
Golf Course Turf	2	Mow, seed, scout, mechanical weed, aerate, fertilize	500	0.241	1.32	7,500	1,400	0.0775	0.0132	1700	9800
		Transplant, high contact	16,500	0.241	1.32 (wet) 0.219 (dry)	230	40 (wet) 250 (dry)	NA	NA	NA	NA
Sod Farms (FL)	4	Mow, scout, mechanical weed, irrigate	500	0.482	2.64	NA	NA	0.155	0.0264	840	4900
Sod Farms	2	Mow, scout, mechanical weed, irrigate	500	0.241	1.32	NA	NA	0.0775	0.0132	1700	9800
Macadamia Nuts/Guava	4	Mow, scout, irrigate (turf under the trees)	500	0.482	2.64	3,800	690	0.155	0.0264	840	4900

Footnotes:

[a]Transfer coefficient from Science Advisory Council for Exposure: Policy Memo # 003 .1 “Agricultural Transfer Coefficients,” Revised - August 7, 2000.

[b]TTR Source: liquid atrazine to turf study MRID # 449580-01, DAT 0-1 residue unless an MOE of >100 was not reached. In such cases risks were assessed on days following application until an MOE of 100 was determined. The highest residue value occurring between DAT 0-1 was used for determination of DAT 1 MOE's. The study was conducted in GA and NC using an application rate of 2.0 lb ai/acre. When assessing activities involving a different application rate than was used in the study, the TTR values were adjusted proportionately to reflect the different application rates. For example, for sod grown in Florida muck, which has a maximum label rate of 4.0 lb ai/acre, adjusted

$$\text{TTR} = \frac{\text{Turf TTR x 4 lb ai/A for sod} \in \text{Florida muck}}{\text{2 lb ai/A for turf}}$$

[c]MOE = Short-term NOAEL (104 mg/kg/day; based on a dermal study)/dermal dose where dose = TTR (µg/cm^2) ***X*** TC (cm^2/hr) ***X*** conversion factor (1 mg/1,000 µg) ***X*** exposure time (8 hrs/day)/body weight (70 kg adult).

[d]TTR Source: liquid atrazine turf study MRID # 449580-01, geometric mean of DAT 0-31 predicted residue. See footnote b for further explanation.

[e] MOE = Intermediate-term NOAEL (1.8 mg/kg/day; based on an oral developmental study)/absorbed dermal dose where absorbed dose = TTR (µg/cm^2) ***X*** TC (cm^2/hr) ***X*** conversion factor (1 mg/1,000 µg) ***X*** exposure time (8 hrs/day) ***X*** dermal absorption (6%)/body weight (60 kg female).

NA = Not applicable to this scenario based on typical application or postapplication activities.

TTR = Turf Transferable Residue

b. Uncertainties and Data Gaps

While uncertainty cannot be completely removed from any pesticide risk assessment, there is a substantial amount of actual field monitoring data for occupational handlers of atrazine in the largest area of use, field crops. The studies support the handler exposure and risk estimates stated here, given that most of the estimates are for typical-to-high application rates and acreage per day. Less data were available for most of the other crops and the fertilizer admixture scenarios. The postapplication risk estimates for field crops and turf are based on acceptable guideline field residue study data and are therefore of high confidence. Most of the remaining occupational postapplication risk estimates were extrapolated from those residue studies using the best available crop-specific transfer coefficients, but are considered more uncertain because of the translation of residue data from one crop to another.

8.0 INCIDENT REPORTS

Based on occupational incident data, atrazine appears to have fewer reported cases with moderate or major effects than other major pesticides. Nonoccupational cases showed a greater frequency of cases with moderate and major effects as well as cases requiring treatment than occupational cases. However, this was based on a relatively small number of cases and there was evidence that these effects may have been coincidental with rather than because of exposure.

For incidents involving children under six years of age, atrazine exposure was most likely to result in minor or moderate symptoms. But it should be noted this was based on relatively few cases: seven children with minor symptoms and two children with moderate symptoms. Dermal and ocular effects accounted for the majority of symptoms associated with exposure to atrazine, though a number of cases also reported gastrointestinal, neurological, and respiratory effects.

California data collected from 1982 through 1996 detailed one case submitted to the California Pesticide Illness Surveillance Program (1982-1996). In this case, a worker used the product to contribute to the production of a commodity. Specific symptoms were not mentioned. On the list of the top 200 chemicals for which the National Pesticide Telephone Network received calls from 1984-1991 inclusively, atrazine was ranked 33rd with 117 incidents in humans reported and 28 incidents in animals (mostly pets). From the review of the Incident Data System, it appears that a majority of cases involved skin illnesses such as dermal irritation and pain, rashes, and welts and eye illnesses such as eye damage, blurred vision, conjunctivitis, irritation, and pain. Poison Control Center data tend to support these findings. Dermal and ocular effects were the most common effects reported due to occupational exposure.

HED concludes that none of the epidemiologic studies reviewed add significant new information concerning the adverse health effects of atrazine. A nonsignificant elevation in nonHodgkin's lymphoma (NHL) continues to be observed at the Louisiana plant among workers exposed to triazines, including atrazine. By itself, this study does not support a conclusion of increased cancer from exposure to triazines. However, this study could be considered supportive, but only supportive and not definitive, if evidence of an association between nonHodgkin's lymphoma and triazine exposure was available from other studies. Follow-up by the National Cancer Institute in four states looked specifically to determine whether earlier associations in individuals studies could be attributed to atrazine when adjustment was made for exposures to other pesticides. They concluded that "detailed analyses suggested that there was little or no increase in the risk of NHL attributable to the agricultural use of atrazine" (Zahm et al. 1993). In January, 2000, Dr. Ruth H. Allen of the Agency reviewed five epidemiological studies with findings related to atrazine, including cancer incidence. The most statistically significant findings related ovarian cancer and atrazine exposure among workers in a corn growing region of Italy. However, there are no studies from other regions to confirm these findings. Other types of cancer in the U.S. were not found to have statistically significant correlation to atrazine exposure.

No major literature citations were found concerning poisoning incidents due to atrazine. There are a number of cancer epidemiology studies of atrazine or triazine herbicides as a group, several of which have been previously reviewed by HED.

9.0 TOLERANCE REASSESSMENT RECOMMENDATIONS

Tolerances established under 40 CFR §180.220(a)(1) are defined for residues of atrazine *per se*. Tolerances established under 40 CFR §180.220(a)(2) are defined for atrazine and its metabolites 2-amino-4-chloro-6-ethylamino-*s*-triazine (G-28279), 2-amino-4-chloro-6-isopropylamino-*s*-triazine (G-30033), and 2-chloro-4,6-diamino-*s*-triazine (G-28273).

In accordance with the Metabolism Assessment Review Committee (MARC) decision dated 11/15/00, the tolerance expression in 40 CFR §180.220(a)(1) should be changed to reflect the combined residues of atrazine and its metabolites: 2-amino-4-chloro-6-ethylamino-*s*-triazine (G-28279), 2-amino-4-chloro-6-isopropylamino-*s*-triazine (G-30033), and 2-chloro-4,6-diamino-*s*-triazine (G-28273). All tolerances based on atrazine and its chloro-metabolites should be placed together under 40 CFR § 180.220 (a)(1). A summary of atrazine tolerance reassessments is presented in Table 20; reassessments are based on tolerances redefined as atrazine and chloro-metabolites.

Also in accordance with the Metabolism Assessment Review Committee (MARC) decision dated 11/15/00, a new tolerance expression for the combined residues of each of the four hydroxy-metabolites: 2-hydroxy-4-ethylamino-6-isopropylamino-s-triazine (G-34048), 2-amino-4-hydroxy-6-isopropylamino-s-triazine (GS-17794), 2-amino-4-hydroxy-6-ethylamino-s-triazine (GS-17792), and 2,4-diamino-6-hydroxy-s-triazine (GS-17791) should be established under 40 CFR § 180.220 (a)(2) once all existing tolerances for atrazine and the chloro-metabolites are placed under 40 CFR §180.220(a)(1). A summary of the tolerances proposed under this new tolerance expression are given in Table 20.

9.1 Tolerances Listed Under 40 CFR §180.220(a)(1)

Tolerances for residues in/on sweet corn forage and fodder can be lowered to 4.0 ppm and 2.0 ppm, respectively, to 1.5 ppm for field/pop corn forages, and to 0.5 ppm for field/pop corn fodder; the designation “fodder” should be revised to “stover.” The tolerances for residues in/on corn, fresh, K+CWHR and corn grain can be decreased to 0.20 ppm, each (based on combined nondetectable residues at 0.05 ppm for atrazine and each chloro-metabolite). The tolerance for residues in/on macadamia nuts can be lowered to 0.20 ppm (based on combined nondetectable residues at 0.05 ppm for atrazine and each chloro-metabolite). Tolerances for residues in/on sorghum forage and fodder can be lowered to 0.50 ppm, each; the designation “fodder” should be revised to “stover.” The tolerance for residues in/on sorghum grain can be lowered to 0.20 ppm (based on combined nondetectable residues at 0.05 ppm for atrazine and each chloro-metabolite). The tolerances for residues in/on wheat fodder, grain, and straw can be lowered to 1.5, 0.10, and 0.50 ppm, respectively; the designation “fodder” should be revised to “forage.” The tolerance for sugar cane can be lowered to 0.2 ppm (based on combined nondetectable residues at 0.05 ppm for atrazine and each chloro-metabolite). The tolerances for residues in/on sugarcane, forage and fodder, should be revoked, as these are no longer regulated as livestock feed items. The tolerance for residues in/on guavas is adequate.

Existing tolerances for residues in commodities from cattle, goats, horses, and sheep (0.02 ppm) must be increased to include combined residues of atrazine and chloro-metabolites. Tolerances have been reassessed based on animal feeding study data. Loss of the atrazine chloro-metabolite, diamino chlorotriazine (G-28273) in liver stored up to 14 months prior to analysis was also considered in the tolerance reassessment. The chloro-metabolite decreased by 45 percent within six months of storage. It is assumed it would decrease by that much again during another six to eight months of storage. If a 45 percent loss occurs after six months of storage, total residues could be further decreased to 20 percent (0.20) of the original concentration after 14 months of storage ($0.02 \div 0.20 = 0.10$ ppm).

The tolerances for commodities from hogs and poultry can be revoked as there is no reasonable expectation of finite residues.

9.2 Proposed Tolerance and Label Amendments

Syngenta proposes lowering the tolerances for sweet and field corn forages to 1.5 ppm, and the tolerance for sorghum forage to 0.25 ppm. For postemergent treatments the registrant proposes a change from a 30-day PHI to a 45-day PHI for sweet corn and sorghum forages, and from a 30-day PHI to a 60-day PHI for field corn forage. Thus eliminating the 30-day PHI for sweet and field corn, and sorghum forages. For preemergent treatments on sorghum, they propose a change from a 45-day PHI to a 60-day PHI. Preemergent treatments on sweet and field corn will retain the existing 45-day and 60-day PHI, respectively. Existing labels contain 21 and 30-day PHIs for corn and sorghum forages.

HED has reassessed the tolerance for sweet corn forages at 4.0 ppm based on field trial data showing the highest chlorotriazine residues detected at 3.2 ppm after a 1X treatment, and a 30-day PHI. Syngenta states that a sweet corn forage tolerance of 1.5 ppm is supported by data representing a 45-day PHI. Maximum chlorotriazine residues on sweet corn forage harvested 45 days after postemergent treatments at the 1X rate expected to result in the highest residues (0.5 + 2.0 lbs ai/A) were approximately 1.15 ppm. HED concludes that if Syngenta amends all atrazine labels for postemergent sweet corn use to allow a minimum PHI of 45 days, they can request the tolerance for sweet corn forage be lowered to 1.5 ppm.

HED has already reassessed the tolerance for field corn forage at 1.5 ppm based on the highest chlorotriazine residues detected at 1.1 ppm after a 1X treatment, at either a 30-day or a 60-day PHI. Maximum chlorotriazine residues on field corn forage harvested 60 days after postemergent treatments at the 1X rate expected to result in the highest residues (0.5 + 2.0 lbs ai/A) were approximately 1.11 ppm. HED concludes that Syngenta should amend all atrazine labels for postemergent field corn use to allow a minimum PHI of 60 days.

The tolerance for sorghum forage has already been reassessed at 0.5 ppm based on field trial data showing the highest chlorotriazine residues detected at 0.22 ppm after a 1X treatment, and a 23-day PHI. Syngenta states that a sorghum forage tolerance of 0.25 ppm is supported by data representing a 45-day PHI. Maximum chlorotriazine residues on sorghum forage harvested 30 and 45 days after **postemergent** treatments at the 1X rate were approximately 0.35 ppm and 0.09 ppm, respectively. Maximum chlorotriazine residues on sorghum forage harvested 45 and 60 days after **preemergent** treatments at the 1X rate were approximately 0.12 and 0.16 ppm, respectively. HED concludes that if Syngenta amends all atrazine labels for postemergent sorghum use to allow a minimum PHI of 45 days, and for preemergent sorghum use to allow a minimum PHI of 60 days, they can request the tolerance for sorghum forage be lowered to 0.25 ppm.

Syngenta proposes that lowering the sweet corn forage tolerance will lower the reassessed milk tolerance as the milk tolerance relates directly to the sweet corn forage tolerance used in estimating a maximum theoretical dietary burden for chlorotriazines in feeds fed to dairy cattle.

HED has recalculated the maximum theoretical dietary burden (MTDB) for dairy cattle based on a reassessed sweet corn forage tolerance of 1.5 ppm. The resulting MTDB for dairy cattle is approximately 2.0 ppm chlorotriazines. Extrapolating the results from cattle feeding studies to this MTDB results in a reassessed milk tolerance of 0.03 ppm. Once Syngenta agrees to amend all atrazine labels to the proposed PHIs discussed above for sweet and field corn forage, and sorghum forage, they can propose lowering the milk tolerance based on available feeding studies and residue data.

9.3 Tolerances Needed Under 40 CFR §180.220(a)(1)

HED proposes establishing a tolerance for residues of atrazine and the chlorinated metabolites in wheat hay based on existing wheat forage residue data, and taking into account any concentration of residues during drying processes for hay. Alternatively, the registrant may submit field trials to determine an appropriate tolerance level for residues in/on wheat hay.

An additional processing study is required for sugarcane, in order to determine the need for a separate tolerance for residues in molasses.

9.4 Tolerances Currently Listed Under 40 CFR §180.220(a)(2) To Be Placed Under 40 CFR §180.220(a)(1)

Currently, there are four products with labelled uses on pasture land and rangeland on terrestrial feed items (forages and fodder) or for road side (right-of-way) uses. Valent Atrazine 90DF (59639-106), Riverside Atrazine 90 DF (9779-253) and Oxon Italia 5L (35915-5) are labelled for application to roadsides at 2 pints and acre, and allow application to Conservation Reserve Program (CRP) land in NE, OR, OK, and TX at 2.2 lbs product/A. Drexel Atrazine 4L (19713-11) is labelled for roadside uses, only. Both of these use patterns include prohibitions against grazing or cutting for hay. Syngenta does not support orchard grass and hay uses. HED recommends that the established tolerances for residues in/on *orchard grass and orchard grass, hay* should be revoked as these uses are not supported by the basic producer.

HED also recommends for the revocation of the 15 ppm tolerance for *Perrenial rye grass*. All product labels must be checked and the use cancelled. The registrant should request cancellation of the use

In addition, the tolerance for *Grass, range* should be revoked and a crop group tolerance for Crop Group 17 (Grass, Forage, Fodder, and Hay) should be established under 180.220(a)(1), which will cover range grasses. Residue data on representative grasses to support the crop group tolerance are recommended. This will include residue data on bermuda grass, bluegrass, and bromegrass or fescue from field trials conducted in concordance with the current label rates. Table 2 of OPPTS 860.1500 Crop Field Trials calls for 12 trials (four for each cultivar). Existing tolerances are believed to be unsupportable based on today's data requirements. If the registrant(s) do not wish to support a crop group tolerance with new residue data, the existing tolerances should be revoked and the uses cancelled.

9.5 Tolerances To Be Established Under 40 CFR § 180.220 (a)(2)

Tolerances for the combined residues of each of the four hydroxy-metabolites: 2-hydroxy-4-ethylamino-6-isopropylamino-s-triazine (G-34048), 2-amino-4-hydroxy-6-isopropylamino-s-triazine (GS-17794), 2-amino-4-hydroxy-6-ethylamino-s-triazine (GS-17792), and 2,4-diamino-6-hydroxy-s-triazine (GS-17791) should be established as listed in Table C for the following 18 raw agricultural commodities: field corn forage and stover; sweet corn forage and stover; pop corn forage and stover; corn, fresh (K+CWHR); field corn grain; guava; macadamia nuts; rye grasses, perennial; sorghum forage and stover; sorghum grain; sugarcane; wheat straw and stover; wheat grain.

HED proposes establishing a tolerance for residues of the hydroxy-metabolites of atrazine in wheat hay based on existing wheat forage residue data, and taking into account any concentration of residues during drying processes for hay. Alternatively, the registrant may submit field trials to determine an appropriate tolerance level for residues in/on wheat hay.

A tolerance for the combined residues of the hydroxy-metabolites of atrazine is needed for sugarcane molasses.

In plant metabolism studies for corn, sorghum, and sugarcane, GS-17794 was the predominant hydroxy triazine metabolite accounting for 50 to 90 percent of the hydroxy triazines detected. On average GS-17794 accounts for 70 percent of the free hydroxy triazine compounds detected in forages, fodders, and sugarcane, and 50 to 70 percent of the free hydroxy triazine compounds detected in grains.

HED concludes that GS-17794 is a suitable marker compound for the hydroxy triazines and may be used to estimate total free hydroxy triazines in crops.

Table 20. Tolerance Reassessment Summary for Atrazine

Commodity	Established Tolerance, ppm	Reassessed Tolerance, ppm	Comments [*Correct Commodity Definition*]
Tolerances Listed Under 40 CFR §180.220(a)(1)[1]			
Cattle, fat	0.02	0.10	Reassessed tolerances based on reassessed sweet corn forage tolerance of 4.0 ppm. Registrant recommended lowering tolerances for sweet corn forage to 1.5 ppm pending amendment of all atrazine labels for postemergent sweet corn use to allow a minimum PHI of 45 days.
Cattle, mbyp	0.02	0.10	
Cattle, meat	0.02	0.10	
Corn, fodder, field	15	0.5	*corn, field, stover*
Corn, fodder, pop	15	0.5	*corn, pop, stover*
Corn, fodder, sweet	15	2.0	*corn, fresh, stover*
Corn, forage, field	15	1.5	Reassessed tolerance based on highest residues of 1.1 ppm after 1X postemergent treatment and a 30- or 60-day PHI. Registrant recommended lowering tolerance to 1.5 ppm pending amendment of all atrazine labels for postemergent sweet corn use to allow a minimum PHI of 45 days.
Corn, forage, pop	15	1.5	
Corn, forage, sweet	15	4.0	Reassessed tolerance based on highest residues of 3.2 ppm after 1X postemergent treatment and a 30-day PHI. Registrant recommended lowering tolerance to 1.5 ppm pending amendment of all atrazine labels for postemergent sweet corn use to allow a minimum PHI of 45 days.
Corn, fresh, K+CWHR	0.25	0.20	
Corn, grain	0.25	0.20	
Eggs	0.02	Revoke	HED concludes that there is no reasonable expectation of finding quantifiable atrazine residues in eggs or the meat, fat, or meat byproducts of poultry

Commodity	Established Tolerance, ppm	Reassessed Tolerance, ppm	Comments [*Correct Commodity Definition*]
Goats, fat	0.02	0.10	Reassessed tolerances based on reassessed sweet corn forage tolerance of 4.0 ppm. Registrant recommended lowering tolerances for sweet corn forage to 1.5 ppm pending amendment of all atrazine labels for postemergent sweet corn use to allow a minimum PHI of 45 days.
Goats, mbyp	0.02	0.10	
Goats, meat	0.02	0.10	
Guava	0.05	0.05	
Hogs, fat	0.02	Revoke	HED concludes that there is no reasonable expectation of finding quantifiable atrazine residues in the meat, fat, or meat byproducts of hogs.
Hogs, mbyp	0.02	Revoke	
Hogs, meat	0.02	Revoke	
Horses, fat	0.02	0.10	Reassessed tolerances based on reassessed sweet corn forage tolerance of 4.0 ppm. Registrant recommended lowering tolerances for sweet corn forage to 1.5 ppm pending amendment of all atrazine labels for postemergent sweet corn use to allow a minimum PHI of 45 days.
Horses, mbyp	0.02	0.10	
Horses, meat	0.02	0.10	
Macadamia nuts	0.25	0.20	
Milk	0.02	0.10	Reassessed tolerances based on reassessed sweet corn forage tolerance of 4.0 ppm. Registrant recommended lowering tolerances for sweet corn forage to 1.5 ppm pending amendment of all atrazine labels for postemergent sweet corn use to allow a minimum PHI of 45 days.
Poultry, fat	0.02	Revoke	HED concludes that there is no reasonable expectation of finding quantifiable atrazine residues in eggs or the meat, fat, or meat byproducts of poultry.
Poultry, mbyp	0.02	Revoke	
Poultry, meat	0.02	Revoke	
Rye, grasses, perennial	15	Revoke	Uses are restricted to the Conservation Reserve Program (CRP) lands in OK, OR, NE, and TX. Restrictions on grazing and cutting for hay apply.

Commodity	Established Tolerance, ppm	Reassessed Tolerance, ppm	Comments [*Correct Commodity Definition*]
Sheep, fat	0.02	0.10	Reassessed tolerances based on reassessed sweet corn forage tolerance of 4.0 ppm. Registrant recommended lowering tolerances for sweet corn forage to 1.5 ppm pending amendment of all atrazine labels for postemergent sweet corn use to allow a minimum PHI of 45 days.
Sheep, mbyp	0.02	0.10	
Sheep, meat	0.02	0.10	
Sorghum, fodder	15	0.50	*Sorghum, stover*
Sorghum, forage	15	0.50	Reassessed tolerances based on highest residues of 0.35 ppm at a 30-day PHI. Registrant recommended lowering tolerance to 0.25 ppm pending amendment of all atrazine labels for postemergent sorghum use to allow a minimum PHI of 45 days, and for preemergent sorghum use to allow a minimum PHI of 60 days.
Sorghum, grain	0.25	0.20	
Sugarcane	0.25	0.20	
Sugarcane, fodder	0.25	Revoke	Not a significant livestock feed item
Sugarcane, forage	0.25	Revoke	Not a significant livestock feed item
Wheat, fodder	5	1.5	*Wheat, forage*
Wheat, grain	0.25	0.10	
Wheat, straw	5	0.50	
Tolerances Listed Under 40 CFR §180.220(a)(2) To be Places Under 40 CFR §180.220(a)(1)[1]			
Grasses, orchardgrass	15	Revoke	Uses on orchard grass are not supported by the basic producer
Grasses, orchardgrass, hay	15	Revoke	Uses on orchard grass are not supported by the basic producer

Commodity	Established Tolerance, ppm	Reassessed Tolerance, ppm	Comments [*Correct Commodity Definition*]
Grasses, range	4	TBD	Uses are restricted to the Conservation Reserve Program (CRP) lands in OK, OR, NE, and TX. Restrictions on grazing and cutting for hay apply. However, these grasses may be fed during drought and emergencies. Registrant may establish a crop group tolerance under Crop Group 17. Residue data on representative crops are recommended. Once data are submitted a crop group tolerance should be established under 180.220(a)(1). Table 2 of OPPTS 860.1500 Crop Field Trials calls for 12 trials (four for each cultivar). Existing tolerances are believed to be unsupportable based on today's data requirements. If the registrant(s) do not wish to support a crop group tolerance with new residue data, the existing tolerances should be revoked and the uses cancelled.
Tolerances Needed Under 40 CFR §180.220(a)(1)[1]			
Sugarcane molasses	none	TBD[2]	additional data are required to determine the need for a separate tolerance
Wheat, hay	none	5	HED proposes this tolerance based on residue data for wheat forage, taking into account concentration of residues as forage is dried to hay. Alternatively, the registrant may provide residue data on wheat hay from field trials.
Tolerances to be Established Under 40 CFR §180.220(a)(2)[3]			
Corn, stover, field	none	4	
Corn, stover, pop	none	4	
Corn, stover, sweet	none	4	
Corn, forage, field	none	2	
Corn, forage, pop	none	2	
Corn, forage, sweet	none	2	
Corn, fresh, K+CWHR	none	0.08	
Corn, grain	none	0.08	
Guava	none	0.05	
Macadamia nuts	none	0.25	
Rye grasses, perennial	none	0.5	

Commodity	Established Tolerance, ppm	Reassessed Tolerance, ppm	Comments [*Correct Commodity Definition*]
Sorghum, stover	none	1	
Sorghum, forage	none	0.5	
Sorghum, grain	none	0.08	
Sugarcane	none	0.08	
Wheat, forage	none	0.5	
Wheat, grain	none	0.08	
Wheat, straw	none	1.0	
Tolerances Needed Under 40 CFR §180.220(a)(2)[3]			
Sugarcane molasses	none	TBD[2]	additional data are required to determine the need for a separate tolerance
Wheat, hay	none	1.5	HED proposes this tolerance based on residue data for wheat forage, taking into account concentration of residues as forage is dried to hay. Alternatively, the registrant may provide residue data on wheat hay from field trials.
Tolerances to be Proposed Under 40 CFR §180.220(d)			
[Indirect residues in foliage of legume vegetables]	none	TBD	additional data are required to determine the need for indirect residue tolerance(s)

[1]Tolerances reassessed based on combined residues of atrazine, G30033, G-28279, and G-28273.

[2]TBD = To be determined. Reassessment of tolerance(s) cannot be made at this time because additional data are required.

[3]Tolerances based on combined residues of 2-hydroxy-4-ethylamino-6-isopropylamino-s-triazine (G-34048), 2-amino-4-hydroxy-6-isopropylamino-s-triazine (GS-17794), 2-amino-4-hydroxy-6-ethylamino-s-triazine (GS-17792), and 2,4-diamino-6-hydroxy-s-triazine (GS-17791).

10.0 DATA NEEDS/LABEL REQUIREMENTS

There are no major data gaps for atrazine. The additional studies and information given below will help to refine the risk estimates and clarify uncertainties.

10.1 Toxicity Data

Although essentially complete, a 28-day inhalation toxicity study measuring LH surge and estrus cycle parameters is required. In addition, a study to assess CNS alterations after atrazine exposure is recommended.

10.2 Residue Chemistry

Additional data on storage stability (OPPTS 860.1380) are required. A required limited rotational crop study has been submitted and is under review (OPPTS 860.1900).

In addition, the tolerance for *Grass, range* should be revoked and a crop group tolerance for Crop Group 17 (Grass, Forage, Fodder, and Hay) should be established under which range grasses would be covered. Residue data on representative grasses to support the crop group tolerance are recommended. This will include residue data on bermuda grass, bluegrass, and bromegrass or fescue. Once data are submitted, and reviewed, a crop group tolerance should be established under 180.220(a)(1). Under Table 2 of OPPTS 860.1500 Crop Field Trials calls for 12 trials (four for each cultivar). Existing tolerances are believed to be unsupportable based on today's data requirements. If the registrant(s) do not wish to support a crop group tolerance with new residue data, the existing tolerances should be revoked and uses cancelled. Uses are restricted to the Conservation Reserve Program (CRP) lands in OK, OR, NE, and TX. Although restrictions on grazing and cutting for hay apply, these grasses may be fed during drought and emergencies.

The tolerance on *orchard grass should be changed to orchard grass forage, and silage. The tolerance for orchard* grass hay is fine. If the registrant chooses to establish a crop group tolerance for Crop Group 17, and provide the necessary residue data to support the crop group tolerance, the individual tolerance for *orchard grass forage, silage, and hay* can be revoked and covered under the crop grouping. The details of these data requirements can be found in Attachment IV.

Tolerances for the hydroxy-metabolites of atrazine are required.

10.3 Drinking Water

Continued monitoring of CWS currently in VMS, and inclusion of the 52 CWS identified in Appendix III.

A continuing program of additional sampling in rural wells identified as in proximity to high use areas, as well as those previously identified as having residues of concern for chronic effects based on a single sample would help to refine risk estimates for populations obtaining their drinking water from these rural wells.

Exposure and risk assessment for CWS using surface water or blended water in states with moderate to low atrazine use.

10.4 Occupational/ Residential

Additional exposure data on the mixing, loading and application of dry and liquid fertilizers both commercially (including cooperatives) and on-farm would help to refine risk estimates for this exposure scenario and clarify uncertainties.

APPENDIX I

Screening-level Exposure and Risk Assessment for Atrazine and the Chlorinated Metabolites in Community Water Systems (CWS) Using Surface Water for Which Data Were Available

SCREENING-LEVEL EXPOSURE ASSESSMENT METHODOLOGY

Screening-level exposure assessments have been conducted for maximum one-day (acute), 90-day average (intermediate-term), and annual average (chronic) exposures to residues of atrazine and the chlorinated metabolites in CWS using surface water. Under the screening-level assessments, for each surface water CWS for which data were available, estimates of maximum and annual average concentrations of the chlorotriazines were estimated. Quarterly (90-day) average concentrations were estimated for a subset of these surface water CWS. Because only one to two concentration values for atrazine and the chlorinated metabolites were available for rural wells and CWS using groundwater, these values were used to represent both maximum and average concentrations. These concentration estimates were compared to drinking water levels of comparison (DWLOCs) for acute and intermediate-term to chronic effects.

A DWLOC is the portion of the acute PAD or chronic PAD remaining after estimated dietary (food only) exposures have been subtracted that has been converted to a concentration (ppb). This concentration value (DWLOC) represents the available or allowable exposure through drinking water for atrazine and the chlorinated metabolites. Under the acute risk assessment, the remaining portion of the acute PAD is based on dietary exposures at the 99.9th percentile of exposure for each relevant population subgroup considered. Under the intermediate-term to chronic risk assessment, the remaining portion of the chronic PAD is based on average dietary exposures for each relevant population subgroup considered. Maximum concentrations of chlorotriazines less than acute DWLOCs, and average concentrations of chlorotriazines less than chronic DWLOCs , do not exceed HED’s level of concern. DWLOC values vary for population subgroups depending on dietary exposure through foods for each subgroup, and the assumptions made about drinking water consumption, and body weights for each subgroup.

Under HED’s screening-level approach to estimate acute risk, the maximum measured one-day concentrations of atrazine and the chlorinated metabolites for each CWS using surface water from each database (PLEX, VMS, and ARP), and each well included in the Rural Well Survey have been compared to theoretical concentration limits (based on acute effects) for atrazine and the chlorinated metabolites in drinking water for relevant population subgroups. The theoretical limits for atrazine and the chlorinated metabolites in drinking water based on acute effects are called acute drinking water levels of comparison (acute DWLOCs). DWLOCs for acute effects are based on the toxic effects identified for atrazine and the chlorinated metabolites resulting from one-day exposures for relevant population subgroups. The maximum and 99th percentile concentration values of all data collected in the “Synoptic” Survey of groundwater CWS were compared to the acute DWLOC.

Under HED's screening-level approach to estimate chronic risk, time-weighted annual mean concentrations for atrazine and the chlorinated metabolites were estimated for each CWS in the PLEX database (1993 through 1999), in the VMS database (June 1993 through 2000), and the ARP database (1995 through 1998) and compared to the DWLOCs for intermediate-term to chronic effects. The year with the maximum annual average total chlorotriazine concentration was reported. For atrazine, *per se*, the time-weighted annual mean concentrations were calculated for each surface water-sourced CWS in the VMS (by Syngenta), ARP (by EFED), and PLEX (by Syngenta) databases. The annual mean concentrations for atrazine and the chlorinated metabolites were estimated by applying the annual regression equation to the time-weighted annual mean atrazine concentrations. Insufficient data (one to two samples per well) were available for rural wells and groundwater CWS to estimate annual mean concentrations. Instead, individual concentration values for rural wells, and the 50th percentile value for all groundwater CWS in the "Synoptic" Survey were compared to the DWLOCs for intermediate-term to chronic effects.

Under HED's screening-level approach to estimate intermediate-term risk, 90-day (quarterly) average concentrations for atrazine and the chlorinated metabolites for each CWS included in the VMS and ARP databases were calculated for January/March, April/June, July/September, and October/December for each year, 1993 through 2000, for each CWS using surface water for which data were available. For each sample reported for a given quarter for a CWS, the relevant regression equation was applied to estimate concentrations of atrazine and the chlorinated metabolites in each sample. Arithmetic averages of concentrations of atrazine and the chlorinated metabolites per quarter were based on the number of samples per quarter. For each CWS, the quarterly averages from 1993 through 2000 were compared to the DWLOCs for intermediate-term to chronic effects, and the quarter with the maximum average concentration of atrazine and the chlorinated metabolites was reported. Insufficient data were available for rural wells and CWS using groundwater to estimate 90-day average concentrations.

DWLOCs for intermediate-term to chronic effects are based on the toxic effects identified for atrazine and the chlorinated metabolites resulting from intermediate-term and chronic exposures for relevant population subgroups. Comparison of 90 day average concentrations (based on VMS and ARP databases) to DWLOC values based on attenuation of the LH surge is considered conservative, but appropriate to estimate risk for intermediate-term to chronic effects. This endpoint was selected from a subchronic (six-month) study in which the effect was seen after four to five months of daily dosing. CWS using surface water with 90-day and/or annual average concentrations of atrazine and the chlorinated metabolites in drinking water greater than the DWLOC values for intermediate-term to chronic effects have been identified for risk analysis using probabilistic techniques. Wells with combined residues of atrazine greater than DWLOC values for intermediate-term to chronic effects have been identified.

HED's screening-level assessments for acute exposure to residues of atrazine and the chlorinated metabolites in drinking water assume that all individuals in the assessment receive the same one-day maximum concentration. Screening-level assessments for intermediate-term to chronic exposure to residues of atrazine and the chlorinated metabolites in drinking water assume that all individuals in the assessment receive the same seasonal concentration daily over a 90-day period, and the same annual average concentration daily over a one year period. All assessments under the screening-level approach assume that all males drink two liters of water per day and weigh 70 kg, all females drink two liters of water per day and weigh 60 kg, and all infants and children drink one liter of water per day and weigh 10 kg. These concentration estimates and exposure factors remain fixed, and do not vary under the screening-level assessment.

These consumption and body weight factors are currently used by the OW in setting water quality standards for human health, i.e., MCLs. The OW's Office of Science and Technology (OST) estimates that 90 percent of the population has a per capita ingestion rate of community water (i.e., tap water from municipal supplies) of two liters or less per day, and that 90 percent of infants less than one year old and children one to 10 years old ingest one liter per day or less. They estimate that community water supplies comprise 75 percent of the total water ingested by the U.S. population, whereas bottled water comprises 13 percent, and spring, private well or cistern water comprises 10 percent.[4] HED notes that the OW has recently completed its "Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (2000)[5]." This document recommends using the same consumption rates as given above, and the following body weights for human health exposure assessments: 76 kg for adult males; 67 kg for pregnant females; 30 kg for children four to 14 years old; 13 kg for toddlers (one to three years old); and 7 kg for infants (<one year old). HED has conducted a separate deterministic risk assessment that includes these newly recommended default values for body weight for comparison.

[4]USEPA, "Estimated Per capita Water Ingestion in the United States, Based on Data Collected by the USDA's 1994-1996 Continuing Survey of Food Intake by individuals," Office of Science and Technology, Office of Water, EPA-822-00-008, April 2000.

[5]U.S. EPA, Office of Water, "Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (2000)." Office of Science and Technology, Office of Water. EPA-822-B-00-004. October 2000, and U.S. EPA Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (2000)". Technical Support Document Volume 1: Risk Assessment. Office of Science and Technology, Office of Water. EPA-822-B-00-005. October

For each CWS identified under the screening-level assessment as having exposures to concentrations of atrazine and the chlorotriazine metabolites in excess of DWLOC values a probabilistic exposure assessment has been conducted. A refined assessment using probabilistic techniques is intended to utilize all available data on residue concentrations, specific populations exposed, consumption, and body weights for those CWS identified under the screening-level assessment approach. By incorporating the variability inherent in distributions of data effecting individual drinking water exposures into this exposure assessment, the estimates of risk are expected to be the most refined possible and have the least uncertainty. The risk estimates are presented below by drinking water source category. These risk estimates are based on the current default assumptions used by the OW for drinking water consumption and body weights: 2L/70 kg for adult males, 2L/60 kg for adult females, and 1L/10 kg for infants and children.

Risk Estimates for One-Day (Acute) Exposures in CWS Using Surface Water

Estimates of acute risk are based on estimates of one-day exposures to residues of atrazine and the chlorinated metabolites in food and drinking water. In this screening-level assessment, HED has estimated acute risk from exposures to residues of atrazine and the chlorinated metabolites in food and drinking water by comparing the maximum measured concentration of atrazine plus an estimation of the chlorinated metabolites in any CWS using surface water from each drinking water monitoring database to the appropriate DWLOC value for acute effects for females 13 to 50 years old. Since the only relevant population subgroup considered under the acute risk assessment is females 13 to 50 years old, the DWLOC value for this subgroup was calculated using the following formula:

$$DWLOCacute\ (ug/L) = \frac{[one-day\ water\ exposure\ (mg/kg\ bw/day)\ x\ body\ weight\ (kg)]}{[water\ consumption\ (L/day)\ x\ 10^{-3}\ mg/ug]}$$

$$one-day\ water\ exposure\ (mg/kg\ bw/day) = [AcutePAD - (one-day)\ food\ exposure\ (mg/kg\ bw/day)\ ]$$

The DWLOC value for acute effects for females 13 to 50 years old was calculated based on a 99.9th percentile one-day food exposure for this subgroup of 0.000041 mg/kg/day, a 60 kg body weight, a 2L/day drinking water consumption rate, and an acute PAD of 0.01 mg/kg/day. The acute DWLOC value (298 ppb) represents the one-day (maximum) concentration of residues of atrazine and the chlorinated metabolites in drinking water for females 13 to 50 years old that is not expected to result in adverse acute health effects after considering one-day exposures to concentrations of atrazine and the chlorotriazine metabolites in food at the 99.9th percentile of exposure. Concentrations of residues of atrazine and the chlorinated metabolites less than 298 ppb do not exceed HED's level of concern for acute effects.

The maximum measured concentrations of atrazine and the chlorinated metabolites detected in each CWS using surface water as contained in the PLEX, the VMS, and the ARP were compared to the acute DWLOC value for females 13 to 50 years old. Because all of the one-day maximum concentrations of chlorotriazines at each CWS from each database are well below the DWLOC value for acute effects, 298 ppb, HED has no concerns regarding acute efects from one-day exposures to atrazine and the chlorinated metabolites in drinking water from CWS using surface water. Table A.I-1 contains the name of the CWS in each database with the highest one-day concentration, the population served by that CWS, and the year that the maximum concentration occurred.

Table A.I-1. Community Water Systems (CWS) Using Surface Water with Highest Maximum One-Day Concentrations of Atrazine Plus Chlorinated metabolites Compared to DWLOC Value for Acute Effects for Females 13 to 50 Years Old

Population Subgroup	Food Exposure @ 99.9th Percentile (mg/kg/day)	acute DWLOC (ppb)	CWS	Maximum Concentration ATZ + CLs (ppb)	Population Served	Population Exposed Above Levels of Concern for Acute Effects
PLEX Database						
Females (13 to 50 years old)	0.000044	298	Gillespie, IL (1996)	59.8	3900	Zero
Syngenta' Voluntary Monitoring Survey (VMS)						
Females (13 to 50 years old)	0.000044	298	Salem, IL (1994)	89	8000	Zero
Acetochlor Registration Partnership (ARP)						
Females (13 to 50 years old)	0.000044	298	Gillespie, IL (1996)	69.1	3900	Zero

Risk Estimates for Intermediate-Term and Chronic Exposures CWS using Surface Water

Estimates of intermediate-term and chronic risk are based on estimates of time-weighted average annual and quarterly average exposures to residues of atrazine and the chlorinated metabolites in drinking water coupled with average exposures in food. In this screening-level assessment, HED has estimated intermediate-term and chronic risk from exposures to concentrations of atrazine and the chlorotriazine metabolites in food and drinking water by comparing the quarterly (three-month) average and the annual average concentrations of atrazine and the chlorinated metabolites in any CWS using surface water from each drinking water monitoring database to DWLOC values for intermediate-term to chronic effects. Comparison of quarterly average concentrations (based on an average of concentrations of atrazine and the chlorotriazine metabolites over three months as estimated from the VMS and ARP databases) to DWLOC values for intermediate-term and chronic effects is considered appropriate to estimate risk because the toxic effect (the attenuation of the LH surge as a biomarker indicative of atrazine's ability to alter hypothalamic-pituitary function in general) occurs between 30 days to five months of daily exposure depending on the dose levels used in the animal studies. DWLOC values for intermediate-term to chronic effects for relevant population subgroups considered under the chronic risk assessment were calculated using the following formula:

$$DWLOC_{chronic}(ug/L) = \frac{chronic\ water\ exposure\ (mg/kg\ bw/day)\ x\ body\ weight\ (kg)}{water\ consumption\ (L/day)\ x\ 10^{-3}\ mg/ug}$$

$$chronic\ water\ exposure\ (mg/kg/day) = [Chronic\ PAD - (average\ food + chronic\ residential\ exposure\ (ADD))\ (mg/kg/day)$$

The DWLOC values intermediate-term and chronic effects for each population subgroup of interest are provided in Table A.I-2. As shown, DWLOC values vary with assumptions about body weights and drinking water consumption rates for each population subgroup. The DWLOC values range from 18 ppb for infants and children's subgroups to 63 ppb for adult male subgroups and 54 ppb for adult female subgroups. These DWLOC values reflect OW's current default assumptions about average body weights for each population subgroup. [Note: There are no anticipated intermediate-term or chronic residential exposures to atrazine.]

Table A.I-2. DWLOC Values for Intermediate-Term to Chronic Effects for Comparison to Average Annual and Quarterly Average Concentrations of Atrazine Plus Chlorinated metabolites Detected in Drinking Water (ppb)

Population Subgroup	Average Food Exposure (mg/kg/day)	IT/Chronic DWLOC (ppb)
General Population	0.000005	63
Infants	0.000008	18
Children 1-6	0.000017	18
Children 7-12	0.000009	18
Females 13-50	0.000003	54
Males 13-19	0.000006	63
Males 20+	0.000003	63
Seniors	0.000003	63

* DWLOC values are based on current OW default assumptions about body weights. IT=intermediate-term

The calculated DWLOC values represent the average quarterly and annual concentration of residues of atrazine and the chlorinated metabolites in drinking water that are not expected to result in adverse health effects after considering average exposures to concentrations of atrazine and the chlorotriazine metabolites in food for each population subgroup of interest. Therefore, 18 ppb represents an upper limit on quarterly and annual chlorotriazine concentrations in drinking water. Time-weighted annual averages used in this assessment were estimated for each CWS using surface water for each year that the CWS was included in the PLEX, VMS, and ARP databases. The quarterly average concentrations were estimated based on weekly, biweekly, or monthly concentrations for each CWS for each year that the CWS was included in the VMS and ARP databases. Quarterly average concentrations were not calculated for CWS in the PLEX database, because of the infrequency of sampling and the availability of richer databases with more frequent monitoring, i.e., the VMS and ARP programs.

The time-weighted annual average concentration of atrazine and the chlorinated metabolites detected in each CWS contained in the PLEX, the VMS, and the ARP were compared to the DWLOC values for intermediate-term to chronic effects presented in Table A.1-2. Table A.I-3 contains the name of the CWS in each database with an annual average concentration approaching, equal to, or greater than 18 ppb, the population served by that CWS, and the year that the highest annual average concentration occurred. Both arithmetic average and time-weighted mean (in parentheses) concentrations are provided for each CWS in the table for comparison. All of the CWS in the PLEX database had average annual concentrations of atrazine and the chlorinated metabolites below the DWLOC values. The highest annual average concentration of atrazine and the chlorinated metabolites in any CWS in the PLEX database was 17 ppb. Two

CWS, Shipman and Hettick both in Illinois, included in the VMS had annual average concentrations of atrazine and the chlorinated metabolites greater than 18 ppb. These annual average concentrations in excess of 18 ppb occurred in 1996. For any given year from 1993 to 2000, all other CWS included in the VMS had average annual concentrations less than 18 ppb. One CWS included in the ARP had an annual average concentration greater than 18 ppb, which occurred in 1996. For any given year from 1995 to 1997, all other CWS included in the ARP had average annual concentrations less than 18 ppb. CWS with the notation "self" in the Comment column of Table A.I-3, supply water to immediate residents, only. CWS with the notation "self/supplier" in the Comment column of Table A.I-3, supply water to immediate residents and sell water to purchasers as noted. These results are summarized in Table A.I-3.

Table A.I- 3. Community Water Systems (CWS) using Surface Water with Highest Time-Weighted Average Annual Concentrations of Atrazine Plus Chlorinated metabolites for Comparison to DWLOC Values for Intermediate-term and Chronic Effects*

Year	CWS	Annual Average Concentration ATZ + CLs (ppb)	Population Served	Lowest IT/Chronic DWLOC (ppb)	Comment
VMS Database					
1996	Shipman, IL	18.9 (21.07)	675**	18	self***
1996	Hettick, IL	18.6 (20.23)	250	18	self
Acetochlor Registration Partnership (ARP)					
1996	Shipman, IL	17.6 (18.72)	675**	18	self

* DWLOC values are based on current OW default assumptions about body weights.

** Reported as 365 to 675 people served.
*** Supplies drinking water to population served by that CWS only.
IT = Intermediate-term

The CWS serving Shipman, IL was included in the VMS program from 1993 through 2000; it was also included in the ARP program from 1995 through 1997. This CWS exceeded an annual mean concentration of 18 ppb in 1996 only, as identified in both the VMS and ARP monitoring programs. The CWS serving Shipman, IL had annual average concentrations below 18 ppb in all other years for which monitoring data were available. The CWS serving Hettick, IL was included in the VMS program from 1993 through 2000; it was not included in the ARP program. This CWS exceeded an annual mean concentration of 18 ppb in 1996 only, as identified in the VMS program. Hettick, IL had annual average concentrations below 18 ppb in all other years for which monitoring data were available. HED notes that the Shipman reservoir (serving 650 people) no longer serves as a drinking water source; in 1999 the town of Shipman was switched to an alternative source of drinking water.

Quarterly average concentrations were estimated for atrazine and the chlorinated metabolites for CWS included in the VMS and ARP programs, in which CWS using surface water were sampled with much greater frequency than the PLEX. The quarterly average concentrations of total chlorotriazines were compared to DWLOC values. The CWS in the VMS and ARP with a quarterly average concentration approaching, equal to, or greater than 18 ppb are provided below in Table A.I- 4. Both arithmetic average and time-weighted mean (in parentheses) concentrations are provided for each CWS in the table for comparison. CWS with the notation “self” in the Comment column of Table A.I- 4, supply water to immediate residents, only. CWS with the notation “self/supplier” in the Comment column of Table A.I- 4, supply water to local residents <u>and</u> sell water to purchasers as noted.

All CWS in Illinois listed under the VMS program for 1993 have been placed in Table A.I- 4 based on one sample taken in June. As such, the chlorotriazine concentration reported for each of these CWS does not represent a quarterly average concentration, but one sample. The values in (parentheses) are time-weighted mean concentrations for these CWS based on samples collected from June through August as estimated by the registrant. These CWS remain candidates for inclusion in a probabilistic risk assessment, because based on the one sample in June, it is possible that high concentrations of chlorotriazines were present in April and May, and the three-month concentrations estimated for most of these CWS are still approaching, equal to, or greater than 18 ppb.

Table A.I- 4. Community Water Systems (CWS) using Surface Water with Highest Seasonal Mean Concentrations of Atrazine Plus Chlorinated metabolites Compared to DWLOC Values for Intermediate-Term to Chronic Effects

Year	CWS	Seasonal Average Concentration ATZ + CLs (ppb)	Population Served	Lowest IT/ Chronic DWLOC (ppb)	Comment
VMS Database					
1999	Marion, KY	18.58 (20.86)	5438	18	self
1999	Dearborn, MO	36.87 (31.40)	600	18	self
1998	Hettick, IL	19.27 (21.16)	250	18	self
1996	Shipman, IL	39.14 (36.38)	675	18	self
1996	Hettick, IL	32.86 (35.91)	250	18	self
1994	Salem, IL	42.45 (38.86)	8000	18	self
1994	Palmyra-Modesto water Co., IL	21.92 (23.83)	60	18	self/supplier
1994	Palmyra, IL	21.92 (23.83)	850	18	purchased water from Palmyra-Modesto Co.
1994	Modesto, IL	21.92 (23.83)	240	18	purchased water from Palmyra-Modesto Co.
1994	Scottsville Rural Water Co., IL	21.92 (23.83)	510	18	purchased water from Palmyra-Modesto Co.
1994	Hillsboro, IL	19.27 (15.46)	4400	18	self/supplier
1994	Coffeen, IL	19.27 (15.46)	736	18	purchased water from Hillsboro
1994	Schram City, IL	19.27 (15.46)	700	18	purchased water from Hillsboro
1994	Taylor Springs, IL	19.27 (15.46)	650	18	purchased water from Hillsboro
1993	Salem, IL	61.61 (26.53)	8000	18	self
1993	Farina, IL	24.79 (20.83)	600	18	self
1993	Kinmundy, IL	24.79 (12.16)	940	18	self
1993	Shipman, IL	24.79 (19.48)	675	18	self
1993	ADGPTV, IL	20.85 (13.22)	1257	18	self/supplier
1993	Girard, IL	20.85 (13.22)	2400	18	purchased water from ADGPTV
1993	Nilwood	20.85 (13.22)	1063	18	purchased water from ADGPTV

Table A.I- 4. Community Water Systems (CWS) using Surface Water with Highest Seasonal Mean Concentrations of Atrazine Plus Chlorinated metabolites Compared to DWLOC Values for Intermediate-Term to Chronic Effects

Year	CWS	Seasonal Average Concentration ATZ + CLs (ppb)	Population Served	Lowest IT/ Chronic DWLOC (ppb)	Comment
1993	Virden	20.85 (13.22)	3650	18	purchased water from ADGPTV
1993	Auburn	20.85 (13.22)	3724	18	purchased water from ADGPTV
1993	Divernon	20.85 (13.22)	1200	18	purchased water from ADGPTV
1993	Pawnee	20.85 (13.22)	2384	18	purchased water from ADGPTV
1993	Thayer	20.85 (13.22)	830	18	purchased water from ADGPTV
1993	Palmyra-Modesto water Co., IL	19.52 (16.79)	60	18	self/supplier
1993	Palmyra, IL	19.52 (16.79)	850	18	purchased water from Palmyra-Modesto Co.
1993	Modesto, IL	19.52 (16.79)	240	18	purchased water from Palmyra-Modesto Co.
1993	Scottsville Rural Water Co., IL	19.52 (16.79)	510	18	purchased water from Palmyra-Modesto Co.
Acetochlor Registration Partnership (ARP)					
1996	Shipman, IL	33.86 (34.42)	675	18	self
1996	Gillespie, IL	32.17 (31.11)	3900	18	self/supplier
1996	Kaho Water District, IL	32.17 (31.11)	847	18	Purchased water from Gillespie
1996	Benld, IL	32.17 (31.11)	1634	18	Purchased water from Gillespie
1996	Dorchester, IL	32.17 (31.11)	531	18	Purchased water from Gillespie
1996	Eagerville, IL	32.17 (31.11)	127	18	Purchased water from Gillespie
1996	Mount Clare, IL	32.17 (31.11)	297	18	Purchased water from Gillespie
1996	Wilsonville, IL	32.17 (31.11)	609	18	Purchased water from Gillespie
1996	Spring Ck Water Assn., IL	32.17 (31.11)	60	18	Purchased water from Gillespie

Table A.I- 4. Community Water Systems (CWS) using Surface Water with Highest Seasonal Mean Concentrations of Atrazine Plus Chlorinated metabolites Compared to DWLOC Values for Intermediate-Term to Chronic Effects

Year	CWS	Seasonal Average Concentration ATZ + CLs (ppb)	Population Served	Lowest IT/ Chronic DWLOC (ppb)	Comment
1996	Scottsburg, IN	22.95 (14.67)	5500	18	self
1995	Holland, IN	21.15 (11.77)	895	18	self

* DWLOC values are based on current OW default assumptions about body weights.

There are 13 CWS that had seasonal mean concentrations approaching, equal to, or greater than 18 ppb between 1993 and 2000. These 13 CWS represent 0.06 percent of the 21,241 CWS included in the PLEX database. These 13 CWS serve a population of approximately 32,500 people. Four of these CWS had seasonal mean concentrations greater than 18 ppb in two out of the six years for which monitoring data were available; Shipman, Hettick, Salem, and Palmyra-Modesto Water Co. These are the same four CWS with annual average concentrations of concentrations of atrazine and the chlorotriazine metabolites greater than 18 ppb identified above in Table A.I- 3. Nine of these CWS are located in Illinois, two in Indiana, one in Kentucky, and one in Missouri. Of the nine CWS located in Illinois, four sold water during the period of 1993 to 1998 to 20 adjacent towns/cities serving an additional 23,000 people. Based on estimates of quarterly average concentrations of chlorotriazines in 13 CWS, potentially 49,500 people may have been exposed to average quarterly concentrations approaching, equal to, or greater than excess of 18 ppb in at least one season during the period 1993 to 2000. Risk estimates for these 13 CWS exceed HED's level of concern for infants and children, only. The U.S. Bureau of Census (2000) estimates that children five years old and under comprise 6.8 percent of the U.S. population.

All CWS during the period of monitoring from 1993 to 2000, had quarterly average concentrations at levels that did not exceed HED's level of concern for any adult (male and female) population subgroup.

The 13 CWS identified for refined probabilistic assessment are: Hettick, Shipman, Salem, Palmyra-Modesto, Hillsboro, Farina, Kinmundy, ADGPTV, and Gillespie in Illinois, Holland and Scottsburg in Indiana, Marion in Kentucky, and Dearborn in Missouri. Distributions of residue data for each of these CWS is available from the VMS and/or ARP databases for use in a refined probabilistic assessment. HED notes that the Shipman reservoir (serving 650 people) no longer serves as a drinking water source; in 1999 the town of Shipman was switched to an alternative source of drinking water.

Newly Recommended Exposure Factors

The results of a separate deterministic risk assessment using recommendations from the OW's final report, "Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (2000)," have been included for consideration. This document recommends using the following daily drinking water consumption rate and body weights for human health exposure assessments for these population subgroups: 2L/76 kg for adult males, 2L/76 kg for adult females, 2L/67 kg for pregnant females, 1L/30 kg for children four to 14 years old, 1L/13 kg for toddlers (one to three years old), and 1L/7 kg for infants (< one year old). DWLOC values for the relevant population subgroups considered in the risk assessments are provided in Table A.I-5.

Table A.I-5. DWLOC Values Using OW's Newly Recommended Body Weights for Comparison to Average Annual and Seasonal Mean Concentrations of Atrazine Plus Chlorinated metabolites Detected in Drinking Water (ppb)

Population Subgroup	Food Exposure @ 99.9th Percentile	Average Food Exposure (mg/kg/day)	DWLOC (ppb) for Acute Effects	DWLOC (ppb) for IT/Chronic Effects*
General Population	N/A	0.000005	N/A	68
Infants	N/A	0.000008	N/A	12.5
Children 1-6	N/A	0.000017	N/A	23
Children 7-12	N/A	0.000009	N/A	53
Females 13-50	0.000044	0.000003	333	60
Males 13-19	N/A	0.000006	N/A	68
Males 20+	N/A	0.000003	N/A	68
Seniors	N/A	0.000003	N/A	68

* DWLOC values are based on OW's newly recommended default assumptions about body weights. "Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (2000)." IT = Intermediate-term

The newly recommended defaults for body weights affect the DWLOC values as shown. For all population subgroups, except infants (<one-year old), DWLOC values increase as a result of increased body weights. The acute DWLOC for the relevant subgroup considered under the acute risk assessment is 333 ppb for females 13 to 50 years old. This DWLOC value is much greater than any measured one-day maxima detected in any CWS or rural well contained in the PLEX, VMS, ARP, and Rural Well Survey as shown previously in Table A.I-1. As a result, HED's level of concern for acute effects resulting from of one-day maximum exposures to atrazine and the chlorinated metabolites under either of the screening-level approaches used to estimate acute risk is not exceeded.

The lowest DWLOC value for intermediate-term to chronic effects is 12.5 ppb for infants (<one-year old). Therefore, based on the OW's newly recommended body weights, 12.5 ppb represents an upper limit on quarterly and annual chlorotriazine concentrations in drinking water. This DWLOC is compared to time-weighted average annual and quarterly average chlorotriazine concentrations in finished drinking water. The results of a comparison of this DWLOC (12.5 ppb) to time-weighted average annual and seasonal mean concentrations of atrazine and the chlorinated metabolites from the PLEX, VMS, and ARP are provided in Tables 6 and 7. Both arithmetic average and time-weighted mean (in parentheses) concentrations are provided for each CWS in the table for comparison. CWS with the notation "self" in the Comment column of Tables A.I-6 and A.I- 7, supply water to immediate residents, only. CWS with the notation "self/supplier" in the Comment column of Tables A.I- 6 and A.I-7, supply water to local residents <u>and</u> sell water to purchasers as noted.

Table A.I-6. Community Water Systems (CWS) using Surface Water with Highest Time-Weighted Average Annual Concentrations of Atrazine Plus Chlorinated metabolites for Comparison to DWLOC Values for Intermediate-term and Chronic Effects

Year	CWS	Annual Average Concentration ATZ + CLs (ppb)	Population Served	Lowest IT/ Chronic DWLOC (ppb)	Comment
PLEX Database					
1999	Marion, KY	11.08 (12.95)	5438	12.5	self
1999	Dearborn, MO	14.47 (15.32)	600	12.5	self
1996	Sardinia, OH	14.98 (14.83)	940	12.5	self
1996	Shipman, IL	13.07 (14.73)	675	12.5	self
1996	Hettick, IL	12.33 (13.56)	220	12.5	self
1996	Gillespie, IL	11.80 (11.87)	3900	12.5	self/supplier**
1994	Drexel, MO	16.97 (18.02)	936	12.5	self
1994	Dearborn, MO	14.33 (15.47)	600	12.5	self
1994	Hillsboro, IL	12.15 (12.09)	4400	12.5	self/supplier**
1994	Palmyra-Modesto, IL	11.65 (12.48)	60	12.5	self/supplier**
VMS Database					
1996	Shipman, IL	18.9 (21.07)	675	12.5	self
1996	Hettick, IL	18.6 (20.23)	250	12.5	self
1996	Carlinville, IL	11.8 (2.15)	6688	12.5	
1994	Salem, IL	13.1 (13.64)	8000	12.5	self
1994	Palmyra-Modesto, IL	13.5 (14.70)	60	12.5	self/supplier
Acetochlor Registration Partnership (ARP)					
1996	Shipman, IL	17.6 (18.72)	365	12.5	self
1996	Gillespie, IL	11.0 (9.79)	7000	12.5	self/supplier

* DWLOC values are based on OW's newly recommended default assumptions about body weights. "Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (2000)."
** These CWS sell water to other CWS. See Tables 3 and 6 for CWS purchasing water from Palmyra-Modesto and Gillespie.

Under this approach to the screening-level assessment, 11 CWS using surface water (nine in addition to the two CWS identified above in Table A.I-3) were identified for probabilistic assessment based on a comparison of average annual concentrations approaching, equal to, or greater than a DWLOC value of 12.5 ppb. These CWS are: Marion (KY), Sardinia (OH), Shipman (IL), Hettick (IL), Carlinville (IL), Salem (IL), Palmyra-Modesto (IL), Gillespie (IL), Drexel (MO), Dearborn (MO), and Hillsboro (IL). The CWS at Gillespie, IL sold water in 1996 to several other towns/cities in Illinois: Kaho Public Water District (serving 847 people), Benld (serving 1634 people), Dorchester (serving 531 people), Eagerville (serving 127 people), Mount Clare (serving 297 people), Wilsonville (serving 609 people), and Spring Creek Water Association (serving 60 people). The CWS at Hillsboro, IL sold water in 1994 to several towns/cities in Illinois: Coffeen (serving 736 people), Schram City (serving 700 people), and Taylor Springs (serving 650 people). The CWS at Palmyra-Modesto, IL sold water in 1994 to several towns/cities in Illinois: Palmyra (serving 850 people), Modesto (serving 240 people), and Scottsville Rural Water Co. (serving 510 people). HED notes that the Shipman reservoir (serving approximately 650 people) no longer serves as a drinking water source; in 1999 the town of Shipman was switched to an alternative source of drinking water.

Table A.I-7 shows the results of the comparison of a 12.5 ppb DWLOC value to quarterly average chlorotriazine concentrations from CWS included in the VMS and ARP approaching, equal to, or greater than 12.5 ppb. Both arithmetic average and time-weighted mean (in parentheses) concentrations are provided for each CWS in the table for comparison.

All CWS in Illinois listed under the VMS program for 1993 have been placed in Table A.I-7 based on one sample taken in June. As such, the chlorotriazine concentration reported for each of these CWS does not represent a quarterly average concentration, but one sample. The values in (parentheses) are time-weighted mean concentrations for these CWS based on samples collected from June through August as estimated by the registrant. These CWS remain candidates for inclusion in a probabilistic risk assessment, because based on the one sample taken in June, it is possible that high concentrations of chlorotriazines were present in April and May, and the three-month concentrations estimated for most of these CWS are still approaching, equal to, or greater than 12.5 ppb.

Table A.I- 7. Community Water Systems (CWS) using Surface Water with Highest Seasonal Mean Concentrations of Atrazine Plus Chlorinated metabolites Compared to DWLOC Values for Intermediate-term to Chronic Effects.

Year	CWS	Seasonal Average Concentration ATZ + CLs (ppb)	Population Served	Lowest IT/ Chronic DWLOC (ppb)	Comment
VMS Database					

Table A.I- 7. Community Water Systems (CWS) using Surface Water with Highest Seasonal Mean Concentrations of Atrazine Plus Chlorinated metabolites Compared to DWLOC Values for Intermediate-term to Chronic Effects.

Year	CWS	Seasonal Average Concentration ATZ + CLs (ppb)	Population Served	Lowest IT/ Chronic DWLOC (ppb)	Comment
2001	Iberville, LA	12.30 (13.34)	10,400	12.5	self
2001	Hettick, IL	12.0 (10.35)	250	12.5	self
1999	Lewisburg, KY	12.15 (11.92)	3257	12.5	self
1999	Marion, KY	18.58 (20.86)	5438	12.5	self
1999	Dearborn, MO	36.87 (31.40)	600	12.5	self
1998	Hettick, IL	19.27 (21.16)	250	12.5	self
1998	Chariton, IA	12.0 (11.25)	4616	12.5	self
1997	Iberville, LA	16.83 (16.01)	10,400	12.5	self
1997	Bucklin, MO	15.71 (8.62)	616	12.5	self
1996	Shipman, IL	39.14 (36.38)	675	12.5	self
1996	Hettick, IL	32.86 (35.91)	250	12.5	self
1996	White Hall, IL	17.51 (14.82)	2950	12.5	
1996	Centralia, IL	17.28 (10.72)	14,274	12.5	
1994	Salem, IL	42.45 (38.86)	8000	12.5	self
1994	Palmyra-Modesto water Co., IL	21.92 (23.83)	60	12.5	self/supplier
1994	Palmyra, IL	21.92 (23.83)	850	12.5	purchased water from Palmyra-Modesto Co.
1994	Modesto, IL	21.92 (23.83)	240	12.5	purchased water from Palmyra-Modesto Co.
1994	Scottsville Rural Water Co., IL	21.92 (23.83)	510	12.5	purchased water from Palmyra-Modesto Co.
1994	Hillsboro, IL	19.27 (15.46)	4400	12.5	self/supplier
1994	Coffeen, IL	19.27 (15.46)	736	12.5	purchased water from Hillsboro
1994	Schram City, IL	19.27 (15.46)	700	12.5	purchased water from Hillsboro
1994	Taylor Springs, IL	19.27 (15.46)	650	12.5	purchased water from Hillsboro
1994	Hettick, IL	16.50 (17.14)	250	12.5	self
1994	Shipman, IL	13.09 (15.37)	675	12.5	self

Table A.I- 7. Community Water Systems (CWS) using Surface Water with Highest Seasonal Mean Concentrations of Atrazine Plus Chlorinated metabolites Compared to DWLOC Values for Intermediate-term to Chronic Effects.

Year	CWS	Seasonal Average Concentration ATZ + CLs (ppb)	Population Served	Lowest IT/ Chronic DWLOC (ppb)	Comment
1994	ADGPTV	11.66 (12.20)	1183	12.5	self/supplier
1993	Salem, IL	61.61 (26.53)	8000	12.5	self
1993	Farina, IL	24.79 (20.83)	600	12.5	self
1993	Kinmundy, IL	24.79 (12.16)	940	12.5	self
1993	Shipman, IL	24.79 (19.48)	675	12.5	self
1993	ADGPTV, IL	20.85 (13.22)	1257	12.5	self/supplier
1993	Girard, IL	20.85 (13.22)	2400	12.5	purchased water from ADGPTV
1993	Nilwood	20.85 (13.22)	1063	12.5	purchased water from ADGPTV
1993	Virden	20.85 (13.22)	3650	12.5	purchased water from ADGPTV
1993	Auburn	20.85 (13.22)	3724	12.5	purchased water from ADGPTV
1993	Divernon	20.85 (13.22)	1200	12.5	purchased water from ADGPTV
1993	Pawnee	20.85 (13.22)	2384	12.5	purchased water from ADGPTV
1993	Thayer	20.85 (13.22)	830	12.5	purchased water from ADGPTV
1993	Palmyra-Modesto water Co., IL	19.52 (16.79)	60	12.5	self/supplier
1993	Palmyra, IL	19.52 (16.79)	850	12.5	purchased water from Palmyra-Modesto Co.
1993	Modesto, IL	19.52 (16.79)	240	12.5	purchased water from Palmyra-Modesto Co.
1993	Scottsville Rural Water Co., IL	19.52 (16.79)	510	12.5	purchased water from Palmyra-Modesto Co.
1993	Wayne City, IL	16.91 (10.43)	1424	12.5	self

Table A.I- 7. Community Water Systems (CWS) using Surface Water with Highest Seasonal Mean Concentrations of Atrazine Plus Chlorinated metabolites Compared to DWLOC Values for Intermediate-term to Chronic Effects.

Year	CWS	Seasonal Average Concentration ATZ + CLs (ppb)	Population Served	Lowest IT/ Chronic DWLOC (ppb)	Comment
Acetochlor Registration Partnership (ARP)					
1997	Batesville, IN	14.67 (7.18)	6500	12.5	
1996	Shipman, IL	33.86 (34.42)	675	12.5	self
1996	Gillespie, IL	32.17 (31.11)	3900	12.5	self/supplier
1996	Kaho Water District, IL	32.17 (31.11)	847	12.5	Purchased water from Gillespie
1996	Benld, IL	32.17 (31.11)	1634	12.5	Purchased water from Gillespie
1996	Dorchester, IL	32.17 (31.11)	531	12.5	Purchased water from Gillespie
1996	Eagerville, IL	32.17 (31.11)	127	12.5	Purchased water from Gillespie
1996	Mount Clare, IL	32.17 (31.11)	297	12.5	Purchased water from Gillespie
1996	Wilsonville, IL	32.17 (31.11)	609	12.5	Purchased water from Gillespie
1996	Spring Ck Water Assn., IL	32.17 (31.11)	60	12.5	Purchased water from Gillespie
1996	Scottsburg, IN	22.95 (14.67)	5500	12.5	
1996	Vandalia, MO	17.10 (11.82)	3000	12.5	
1996	White Hall, IL	16.40 (14.78)	2900	12.5	
1996	Flora, IL	12.29 (11.18)	6630	12.5	self
1996	Sorento, IL	11.94 (10.47)	6500	12.5	self
1995	Holland, IN	21.15 (11.77)	895	12.5	
1995	West Salem, IL	17.26 (9.95)	1120	12.5	
1995	North Vernon, IN	12.74 (9.83)	9056	12.5	
1995	Carlinville, IL	12.28 (12.19)	8000	12.5	self

* DWLOC values are based on OW's newly recommended default assumptions about body weights. "Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (2000)."

The CWS identified in Tables 6 and 7 under the screening-level assessment for intermediate-term to chronic effects were identified for probabilistic assessment based on a comparison of average seasonal concentrations of atrazine and the chlorinated metabolites to a DWLOC value of 12.5 ppb. In total, under the screening-level assessment, 29 CWS were identified with quarterly average concentrations of atrazine and the chlorinated metabolites above levels of concern for infants and children. They represent variously 0.14 percent of all CWS monitored under the SDWA using either surface or groundwater or a blend, 0.59 percent of the 4,886 CWS using surface water, and 0.79 percent of the 3,670 CWS using surface water with data on concentrations of atrazine and the chlorotriazine metabolites. Under this screening-level assessment, these 29 CWS have been identified for probabilistic risk assessment. These CWS are: Gillespie, Hettick, Shipman, Salem, Palmyra-Modesto, Hillsboro, Farina, Kinmundy, ADGPTV, Carlinville, West Salem, Flora, Sorento, White Hall, Centralia, and Wayne City in Illinois, Chariton in Iowa, Iberville in Louisiana, Batesville, Holland, North Vernon, and Scottsburg in Indiana, Lewisburg and Marion in Kentucky, Bucklin, Dearborn, Drexel, and Vandalia in Missouri, and Sardinia in Ohio. These 29 CWS are monitored under the SDWA for atrazine, and they serve approximately 142,000 people of which 6.8 percent (2000 Census) are five years old or younger, and 1.4 percent are one-year old or less.

HED notes that the Shipman reservoir (serving approximately 650 people) no longer serves as a drinking water source; in 1999 the town of Shipman was switched to an alternative source of drinking water. The drinking water source at Whitehall was switched from surface water to groundwater in 1997.

APPENDIX II

Probabilistic Exposure and Risk Assessment (PRA) for Atrazine and the Chlorinated Metabolites in 28 CWS Using Surface Water

PROBABILISTIC EXPOSURE ASSESSMENT METHODOLOGY FOR ATRAZINE AND THE CHLORINATED METABOLITES IN 28 CWS

The methodology used in the probabilistic assessments of exposure to atrazine and the chlorinated metabolites for each of 28 CWS is described below.

CWS Included

Under the screening-level exposure assessment, HED concludes that intermediate-term exposure to atrazine and the chlorinated metabolites in drinking water occurring during spring through summer was the exposure pathway and scenario of concern. All other drinking water and food exposure scenarios analyzed using a screening-level approach resulted in risk estimates that were below HED's levels of concern. HED identified 29 CWS using surface water with seasonal exposures to atrazine and the chlorinated metabolites exceeding levels of concern for infants and children. Consequently, HED concluded that exposure estimates for these 29 CWS should be refined using all of the available data in a probabilistic exposure assessment.

In response, the registrant (Syngenta) provided a probabilistic exposure assessment for aggregate exposures to atrazine and the chlorinated metabolites in the drinking water at each of 28 CWS. Of these 28 CWS, 25 were those CWS previously identified by HED for probabilistic exposure assessment. Syngenta included separate probabilistic assessments for an additional three CWS. Exposures at each of these 28 CWS were assessed separately. Exposures at four of the 29 CWS identified under HED’s screening-level assessment were not assessed probabilistically and remain of concern.

Populations Considered

The submitted probabilistic exposure assessment considered infants (<one-year old), children one to six, children seven to 12, and adults 13 to 50 (males and females). In the assessment, drinking water consumption rates and dietary (food) consumption patterns were not linked for an individual (i.e., water and food consumption were assumed to be independent), and the assessments for males and females were combined.

Duration of Exposure

Estimates of exposures to atrazine and the chlorinated metabolites in drinking water in each of the 28 CWS were determined for exposures of an intermediate-term (90-day) duration. Estimates of 90-day moving or rolling average exposures were determined for each of 52 sets of sequential 90-day periods where the periods were each offset by one week. Specifically, for each year of drinking water monitoring data, the starting points for the 90-day average exposures were January 1st, January 8th, January 15th..., through December 24th. For each population subgroup per CWS, the probabilistic assessment includes 10,000 estimates of 90-day average exposures for each of the 52 sets of 90-day exposure periods or 520,000 estimates of 90-day average exposures per subgroup per CWS.

Estimating Intermediate-Term (90-Day) Drinking Water Exposures Probabilistically for Each of 28 CWS

Drinking water exposure estimates for an individual in mg/kg/day are the product of the estimated concentration of atrazine and the chlorometablites in the individual's drinking water in mg/L and the individual's reported consumption of drinking water on a L/day basis divided by the individual's body weight in kg. To estimate drinking water exposures to atrazine and the chlorometablites for each of the 28 CWS, the full distribution of drinking water consumption rates (ml/kg/day) as reported for each individual included in the USDA's 1994 to 1996 and 1998 CSFII and the full distribution of concentration values as collected under the PLEX, ARP, and the VMS databases were used.

To estimate concentrations of atrazine and the chlorometabolites for each of the 28 CWS identified, data collected on finished drinking water specific to that CWS were compiled from the Voluntary Monitoring Program sponsored by the registrant, the Safe Drinking Water Act (SDWA), and the Acetochlor Registration Partnership (ARP). Data from these three data sets on atrazine concentrations in finished drinking water were pooled for each of the 28 CWS, separately. Monitoring data were not combined across CWS. Under each of these monitoring programs, samples of finished drinking water were taken and analyzed for atrazine, *per se.* Concentrations of the chlorotriazine metabolites for each CWS were estimated (see Attachment VII to HED's revised preliminary risk assessment), and added to the measured concentrations of atrazine, *per se*, to arrive at the total chlorotriazine concentrations used in the assessments. Data on finished drinking water were collected across these various monitoring programs during the period from 1993 to 2001 were used in the assessment.

Because the frequency of sampling under any of the monitoring programs was at best weekly, daily concentration values for each CWS were estimated by combining the above datasets, and interpolating. That is, if there is more than one observation on the same date for any given specific water system, then that date's total chlorotriazine concentration is the arithmetic average of all the observations on that date. The total chlorotriazine concentrations for all the days in the month of the first observation before the day of the first observation are set equal to the total chlorotriazine concentration on the first observation day. For the first half of the days between two observations, the total chlorotriazine concentration is set equal to the concentration for the first observation day; for the second half of the days between two consecutive observations, the total chlorotriazine concentration is set equal to the concentration for the second observation day. Finally, the total chlorotriazine concentrations for all the days in the month of the last observation after the day of the last observation are set equal to the total chlorotriazine concentration on the last observation day.

For each year of monitoring data, the resulting chlorotriazine concentration profile consists of 365 daily sequential estimates of chlorotriazine concentrations plus an 82 day profile of daily concentrations from the beginning of the succeeding year resulting in a residue profile of 447 sequential daily chlorotriazine concentration values for each full year of data. If there are no concentration values for the succeeding year, a 365 day concentration profile for the selected year was constructed. This provides 52 sets of daily drinking water chlorotriazine concentration estimates over sequential, 90-day periods offset by one week throughout the year.

To estimate drinking water consumption and body weight profiles for each of the 28 CWS identified, a water consumption profile was constructed from the two-day records available from the 1994 to 1996 and 1998 CSFII data. Each individual's 90 day water consumption profile was generated by randomly sampling, repeatedly for each day in the 90 day period of interest, one of his two day records in order to generate, for each individual, a 90-day water consumption record. For each CWS, four population subgroups were assessed: infants (< one year old), children one to six, children seven to 12, and adults 13 to 50 (males and females). For each subgroup, daily exposures to chlorotriazines in drinking water over a period of 90 consecutive days were estimated for each of 52 starting dates separated by one week, i.e., January 1st, January 8th, January 15th, through December 24th. The average 90-day exposure was calculated for each of the 52 consecutive 90-day periods. The resulting distribution of 90-day average exposures for each of 52 weekly start dates contains 10,000 values per population subgroup. This resulted in 520,000 90-day average exposure values for each subgroup for each of the 28 CWS assessed.

For a specific CWS, an individual was selected from the CSFII to represent a given age/sex subgroup. The age subgroups considered were as described above (i.e., infants (<one year old), children one to six, children seven to 12, and adults 13 to 50). For example, an individual infant from the CSFII consumption profile was selected to obtain necessary drinking water consumption rate and body weight data for exposure calculation. Next, a year in which drinking water data were collected (e.g., 1995) was randomly selected. Finally, the chlorotriazine concentration value, associated with January 1 of that year from the chlorotriazine concentration profile for that year is combined with the one of the two selected individual infant's reported drinking water consumption rates and body weight information from the CSFII consumption profile to estimate the daily chlorotriazine drinking water exposure for January 1st, 1995.

This process is repeated for this same individual infant for the following calendar day (January 2, 1995) and is repeated for each day in the selected year to provide a profile of daily exposures over 90 consecutive days. The average 90-day exposure is then calculated for that 90-day period. This process is repeated with a new individual infant, then another, then another until 10,000 90-day average exposure values (based on a starting date of January 1st) per subgroup are generated. [Note: Because the database for infants does not contain 10,000 individuals the same individual infant will be resampled many times during the course of the assessment. This is true of the other population subgroups as well.

The process begins again for the population subgroup of infants based on a chlorotriazine concentration beginning the week of January 8th (and continuing for the 90 consecutive days beyond that), and again for infants based on a chlorotriazine concentration beginning the week of January 15th and on through the week of December 24th until 90-day average exposures for infants associated with the specific CWS have been estimated for all 52 start dates. The resulting distribution of exposures for the population subgroup of infants contains 10,000 90-day average exposure estimates/52 weekly start dates for a total of 520,000 90-day average exposure estimates for the infants subgroup for the selected CWS. The process is repeated for the other population subgroups for the selected CWS for a total of two million 90-day exposure estimates per CWS. This is done for each of the 28 CWS for a total of 60 million 90-day average exposure estimates for all CWS. In summary, the 90-day average exposure moves forward in weekly increments so that the resulting distribution of drinking water exposures for any year of monitoring data contains 52 sets of sequential 90-day average exposures representing 90-day average exposures over the 1993 to 2001 period.

Estimating Dietary (Food) Exposures

The assessment included average daily dietary exposure (mg/kg/day) to the chlorotriazines through food as a point estimate. That is, the assessments assume that an individual within a specific age/sex population subgroup receives the <u>same daily</u> (constant) exposure to chlorotriazines in food during the exposure period assessed. Because the one-day and average annual dietary exposures to the chlorotriazines are insignificant (orders of magnitude less) than drinking water exposures in these CWS, the chronic average dietary exposure was used to represent average 90-day dietary exposures in the probabilistic assessments.

Point estimates of dietary exposure were taken from HED's chronic dietary assessment as given in Attachment V to HED's final risk assessment. HED's dietary assessment included anticipated residue concentrations of chlorotriazines in foods combined with average dietary consumption of food and average body weights collected under the CSFII 1989-1992. The results of that chronic dietary assessment for exposure to chlorotriazines in foods are given below.

Chronic Dietary Exposure	
Population Subgroup	Average Daily Dietary Exposure (mg/kg/day)
Infants (< 1 year old)	0.000008
Children 1 to 6	0.000017
Children 7 to 12	0.000009
Females/ Males 13 to 50	0.0000045*

*Based on an average of adult male and female average dietary exposures. [0.000003 mg/kg/day + 0.000006 mg/kg/day ÷ 2 = 0.0000045 mg/kg/day]

Combining Food and Drinking Water Exposures

Average food exposure from HED’s chronic dietary exposure assessment for the relevant population assessed: infants (<one year old), children one to six, children seven to 12, and adults 13 to 50 (males and females) were added in as a point estimate to the estimated 90 day average drinking water exposures. In the assessment, an individual's water consumption rate and daily concentration value of chlorotriazines varies from day to day within the exposure period of interest, whereas the food exposure is fixed. Under the screening-level assessment, an individual's water consumption rate and daily concentration value of chlorotriazines and food exposure remained fixed during the exposure period of interest. The resulting distributions of exposure from the probabilistic assessment capture more variability than the estimates of exposure obtained from the screening-level assessment.

The resulting distributions of exposure provide an estimate of total dietary (food and drinking water) exposures to chlorotriazines for infants (< 1 year old), children one to six, children seven to 12, and adults 13 to 50 (males and females) over sequential, 90 day periods offset by one week in each of the 28 CWS assessed probabilistically. The 95^{th}, 99^{th}, and 99.9^{th} percentiles of exposure were compared to the relevant toxic endpoint for intermediate-term effects (0.0018 mg/kg/day) to estimate the risks associated with these chlorotriazine exposures in food and drinking water for each of the 28 CWS.

Tables 1, 2 and 3 contain maximum average 90-day exposures to chlorotriazines in drinking water combined with average dietary exposures through food at the 99.9^{th}, 99^{th}, and 95^{th} percentiles of exposure for the period 1993 through 2001. The registrant also provided a comparison of the results of probabilistic exposure assessments at the 99.9^{th} percentile using two different aggregate exposure models, DISTGEN™ and CALANDEX™. Those results are presented in Tables 1 and 5. The methodology used and the overall results between the two models were quite similar.

Table A.II-1. Risk Estimates for High Seasonal Exposures to Atrazine in Finished Drinking Water and Average Dietary Exposure @ the 99.9th Percentile of Exposure* (Calandex™)

Community Water System (City/State)	Infant's Exposure (mg/kg/day)	% cPAD	Children's Exposure (mg/kg/day)	% cPAD	Adult's Exposure (mg/kg/day)	% cPAD
Chariton, IA	0.0042	235	0.0015	<100	0.0011	<100
Sorento, IL	0.0033	183	0.0013	<100	0.0010	<100
Flora, IL	0.0038	211	0.0017	<100	0.0012	<100
W. Salem, IL	0.0034	189	0.0018	100	0.0014	<100
Farina, IL	0.0034	189	0.0012	<100	0.0008	<100
White Hall, IL	0.0050	278	0.0021	117	0.0014	<100
Carlinville, IL	0.0023	128	0.0011	<100	0.0008	<100
Gillespie, IL	0.0099	550	0.0040	222	0.0031	172
Hettick, IL	0.0098	544	0.0040	222	0.0031	172
Shipman, IL	0.0008	<100	0.0004	<100	0.0003	<100
Palmyra-Modesto, IL	0.0063	350	0.0028	155	0.0020	111
N. Otter Twp ADGPTV, IL	0.0034	189	0.0015	<100	0.0010	<100
Kinmundy, IL	0.0027	150	0.0011	<100	0.0008	<100
Salem, IL	0.0095	528	0.0048	267	0.0036	200
Centralia, IL	0.0046	255	0.0018	100	0.0013	<100
Hillsboro, IL	0.0049	272	0.0021	117	0.0015	<100
Wayne City, IL	0.0004	<100	0.0002	<100	0.0002	<100
Louisville, IL	0.0062	344	0.0022	122	0.0017	<100
Holland, IN	0.0044	244	0.0023	128	0.0017	<100
North Vernon, IN	0.0036	200	0.0021	117	0.0014	<100
Batesville, IN	0.0047	261	0.0020	111	0.0014	<100
Scottsburg, IN	0.0048	267	0.0027	150	0.0019	105%
Iberville, LA	0.0047	261	0.0021	117	0.0015	<100
Higginsville, MO	0.0013	<100	0.0005	<100	0.0003	<100
Bucklin, MO	0.0045	250	0.0018	100	0.0012	<100
Vandalia, MO	0.0034	189	0.0019	105	0.0013	<100
Sardinia, OH	0.012	667	0.0055	305	0.0037	205
Newark, OH	0.0020	111	0.0009	<100	0.0006	<100

Table A.II-2. Risk Estimates for High Seasonal Exposures to Atrazine in Finished Drinking Water and Average Dietary Exposure @ the 99th Percentile of Exposure* (Calandex™)

Community Water System (City/State)	Infant's Exposure (mg/kg/day)	% cPAD	Children's Exposure (mg/kg/day)	% cPAD	Adult's Exposure (mg/kg/day)	% cPAD
Chariton, IA	0.0023	128	0.0009	<100	0.0005	<100
Sorento, IL	0.0020	111	0.0007	<100	0.0005	<100
Flora, IL	0.0025	139	0.0010	<100	0.0006	<100
W. Salem, IL	0.0025	139	0.0010	<100	0.0006	<100
Farina, IL	0.0015	<100	0.0007	<100	0.0004	<100
White Hall, IL	0.0033	183	0.0012	<100	0.0008	<100
Carlinville, IL	0.0017	<100	0.0006	<100	0.0004	<100
Gillespie, IL	0.0061	339	0.0022	122	0.0015	<100
Hettick, IL	0.0060	333	0.0023	128	0.0016	<100
Shipman, IL	0.0005	<100	0.0002	<100	0.0001	<100
Palmyra-Modesto, IL	0.0037	205	0.0014	<100	0.0009	<100
N. Otter Twp ADGPTV, IL	0.0020	111	0.0008	<100	0.0005	<100
Kinmundy, IL	0.0018	100	0.0006	<100	0.0004	<100
Salem, IL	0.0065	361	0.0028	155	0.0018	100
Centralia, IL	0.0027	150	0.0010	<100	0.0006	<100
Hillsboro, IL	0.0028	155	0.0011	<100	0.0007	<100
Wayne City, IL	0.0003	<100	0.0001	<100	0.0001	<100
Louisville, IL	0.0034	189	0.0015	<100	0.0009	<100
Holland, IN	0.0030	167	0.0013	<100	0.0008	<100
North Vernon, IN	0.0027	150	0.0011	<100	0.0007	<100
Batesville, IN	0.0031	172	0.0011	<100	0.0007	<100
Scottsburg, IN	0.0035	194	0.0014	<100	0.0009	<100
Iberville, LA	0.0031	172	0.0013	<100	0.0009	<100
Higginsville, MO	0.0008	<100	0.0003	<100	0.0002	<100
Bucklin, MO	0.0030	167	00.10	<100	0.0007	<100
Vandalia, MO	0.0025	139	00.10	<100	0.0006	<100
Sardinia, OH	0.0076	422	0.0029	161	0.0020	111
Newark, OH	0.0014	<100	0.0005	<100	0.0003	<100

Table A.II-3. Risk Estimates for High Seasonal Exposures to Atrazine in Finished Drinking Water and Average Dietary Exposure @ the 95th Percentile of Exposure* (Calandex™)

Community Water System (City/State)	Infant's Exposure (mg/kg/day)	% cPAD	Children's Exposure (mg/kg/day)	% cPAD	Adult's Exposure (mg/kg/day)	% cPAD
Chariton, IA	0.0011	<100	0.0004	<100	0.0003	<100
Sorento, IL	0.0011	<100	0.0004	<100	0.0003	<100
Flora, IL	0.0016	<100	0.0006	<100	0.0004	<100
W. Salem, IL	0.0014	<100	0.0005	<100	0.0003	<100
Farina, IL	0.0010	<100	0.0004	<100	0.0002	<100
White Hall, IL	0.0017	<100	0.0006	<100	0.0004	<100
Carlinville, IL	0.0008	<100	0.0003	<100	0.0002	<100
Gillespie, IL	0.0033	183	0.0012	<100	0.0008	<100
Hettick, IL	0.0035	194	0.0013	<100	0.0008	<100
Shipman, IL	0.0004	<100	0.0001	<100	0.0001	<100
Palmyra-Modesto, IL	0.0018	100	0.0007	<100	0.0005	<100
N. Otter Twp ADGPTV, IL	0.0011	<100	0.0004	<100	0.0003	<100
Kinmundy, IL	0.0009	<100	0.0003	<100	0.0002	<100
Salem, IL	0.0039	217	0.0015	<100	0.0010	<100
Centralia, IL	0.0014	<100	0.0006	<100	0.0004	<100
Hillsboro, IL	0.0014	<100	0.0006	<100	0.0004	<100
Wayne City, IL	0.0002	<100	0.0001	<100	0.00	<100
Louisville, IL	0.0023	128	0.0009	<100	0.0005	<100
Holland, IN	0.0015	<100	0.0006	<100	0.0004	<100
North Vernon, IN	0.0017	<100	0.0006	<100	0.0004	<100
Batesville, IN	0.0016	<100	0.0006	<100	0.0004	<100
Scottsburg, IN	0.0018	100%	0.0007	<100	0.0005	<100
Iberville, LA	0.0021	117	0.0008	<100	0.0005	<100
Higginsville, MO	0.0004	<100	0.0002	<100	0.0001	<100
Bucklin, MO	0.0012	<100	0.0005	<100	0.0003	<100
Vandalia, MO	0.0014	<100	0.0005	<100	0.0003	<100
Sardinia, OH	0.0043	239	0.0015	<100	0.0010	<100
Newark, OH	0.0008	<100	0.0003	<100	0.0002	<100

Table A.II-4. Duration of Sequential 90-Day Average Exposure $\geq$1 00% PAD @ 99.9th Percentile for Infants (<one year old)

CWS	Approximate Time Period
Chariton, IA	April through September (calendar weeks 13 - 37) 1998
Sorento, IL	mid-April through mid-October (calendar weeks 14 - 43) 1996
Flora, IL	March through July (calendar weeks 8 - 24) 1996
West Salem, IL	March through September (calendar weeks 8 - 37) 1995
Farina, IL	March through December (calendar weeks 9 - 52) 1993
White Hall, IL	January through December (calendar weeks 1 - 52) 1996
Carlinville, IL	May through September (calendar weeks 17 - 33) 1995
Gillespie, IL	March through July (calendar weeks 7 - 28) 1996
Hettick, IL	January through December (calendar weeks 1 - 52) 1996
Palmyra-Modesto, IL	February through December (calendar weeks 5 - 52) 1993 & 1994
AGDPTV, IL	March through July (calendar weeks 8 - 29) 1993 & 1994
Kinmundy, IL	July through October (calendar weeks 24 - 42) 1993
Salem, IL	February through September (calendar weeks 6 - 36) 1993 & 1994
Centralia, IL	April through September (calendar weeks 13 - 37) 1996
Hillsboro, IL	March through May (calendar weeks 7 - 21) 1994
Louisville, IL	March through June (calendar weeks 7 - 24) 2000
Holland, IN	May through January (calendar weeks 16 - 4) 1995
North Vernon, IN	April through July (calendar weeks 12 - 27) 1995
Batesville, IN	May through December (calendar weeks 18 - 52) 1997
Scottsburg, IN	May through October (calendar weeks 16 - 40) 1996
Iberville, IN	November through April (calendar weeks 46 - 15) 1997
Bucklin, MO	May through December (calendar weeks 17 - 50) 1997
Vandalia, MO	May through July (calendar weeks 16 - 30) 1996
Sardinia, OH	March through July (calendar weeks 8 - 27) 1996

Table A.II-5. Risk Estimates for High Seasonal Exposures to Atrazine in Finished Drinking Water and Average Dietary Exposure @ the 99.9th Percentile of Exposure* (Distgen™)

Community Water System (City/State)	Infant's Exposure (mg/kg/day)	% cPAD	Children's Exposure (mg/kg/day)	% cPAD	Adult's Exposure (mg/kg/day)	% cPAD
Chariton, IA	0.0037	205	0.0013	<100	0.0014	<100
Sorento, IL	0.0031	172	0.0013	<100	0.0009	<100
Flora, IL	0.0038	211	0.0016	<100	0.0011	<100
W. Salem, IL	0.0026	144	0.0018	100	0.0015	<100
Farina, IL	0.0029	161	0.0011	<100	0.0011	<100
White Hall, IL	0.0051	283	0.0018	100	0.0010	<100
Carlinville, IL	0.0028	156	0.0012	<100	0.0009	<100
Gillespie, IL	0.0096	533	0.0041	228	0.0023	128
Hettick, IL	0.0093	517	0.0040	222	0.0024	133
Shipman, IL	0.0006	<100	0.0004	<100	0.0002	<100
Palmyra-Modesto, IL	0.0045	250	0.0029	161	0.0019	106
N. Otter Twp ADGPTV, IL	0.0024	133	0.0015	<100	0.0010	<100
Kinmundy, IL	0.0020	111	0.0011	<100	0.0007	<100
Salem, IL	0.0083	461	0.0050	278	0.0041	228
Centralia, IL	0.0048	267	0.0017	<100	0.0012	<100
Hillsboro, IL	0.0036	200	0.0023	128	0.0016	<100
Wayne City, IL	0.0004	<100	0.0003	<100	0.0002	<100
Louisville, IL	0.0044	244	0.0024	133	0.0017	<100
Holland, IN	0.0034	189	0.0024	133	0.0022	122
North Vernon, IN	0.0043	239	0.0019	106	0.0017	<100
Batesville, IN	0.0048	267	0.0017	<100	0.0010	<100
Scottsburg, IN	0.0059	328	0.0026	144	0.0022	122
Iberville, LA	0.0046	256	0.0021	117	0.0017	<100
Higginsville, MO	0.0010	<100	0.0005	<100	0.0003	<100
Bucklin, MO	0.0032	178	0.0016	<100	0.0010	<100
Vandalia, MO	0.0041	228	0.0018	100	0.0014	<100
Sardinia, OH	0.0112	622	0.0049	272	0.0037	206
Newark, OH	0.0015	<100	0.0009	<100	0.0005	<100

APPENDIX III

Additional 52 CWS Using Surface Water with Quarterly Maximum Concentrations of 12.5 ppb

HED has identified another 52 CWS in the PLEX database with quarterly maxima of 12.5 ppb or greater. HED considers these CWS as candidates for inclusion in the VMS monitoring program, as well, unless already included.

The table below contains 52 CWS for inclusion in the ongoing VMS program.

Table A.III-1. Community Water Systems (CWS) with Quarterly Maximum Concentrations of Atrazine plus Chloro-Metabolites Equal to or Greater than 12.5 ppb

Year	CWS	Concentrations (ppb)	Comment
1998	Kansas City, KS	14.42	Self
1998	Defiance, OH	13.63	Self
1998	Ayersville, OH	13.63	Purchases from Defiance
1998	Cristi Meadows Subdivision, OH	13.63	Purchases from Defiance
1998	Brunersburg, OH	13.63	Purchases from Defiance
1998	Village of Blanchester, OH	12.47	Self
1998	Glasgow, MO	15.69	Self
1998	Howard Co. PWD #2	15.69	Purchase from Glasgow
1998	Waverly, IL		Self
1997	Newark, OH	29.7	Self
1997	Delaware, OH	19.8	Self
1997	Lake of the Woods	18.1	Self
1997	Napoleon, OH	17.9	Self
1997	Liberty Center, OH	17.9	Purchased water from Napoleon
1997	Florida City, OH	17.9	Purchased water from Napoleon
1997	Village of Malinta, OH	17.9	Purchased water from Napoleon
1997	Aquilla Water Supply District, TX	15.13	Self
1997	Brandon-Irene Water Supply Corp. TX	15.13	Self
1997	Chatt Water Supply Corp., TX	15.13	Self
1997	Files Valley Water Corp.	15.13	Self
1997	Hill Co. Water Corp., TX	15.13	Self
1997	Milford City, TX	15.13	Self
1997	City of Bynum, TX	15.13	Self
1997	Piqua, OH	14.31	Self
1997	Village of Mt. Orab, OH	12.87	Self
1997	Clermont Co., OH	12.62	Self

Table A.III-1. Community Water Systems (CWS) with Quarterly Maximum Concentrations of Atrazine plus Chloro-Metabolites Equal to or Greater than 12.5 ppb

Year	CWS	Concentrations (ppb)	Comment
1996	Napoleon, OH	14.65	Self/supplier
1996	Sardinia, OH	55.2	
1996	Louisville, IL	24.3	
1996	Osawatomie, KS	17.3	
1996	Miami Co. RWD #1, KS	17.3	Purchased water from Osawatomie
1996	Miami Co. RWD #3, KS	17.3	Purchased water from Osawatomie
1996	City of Osage, KS	15.84	Self
1996	Osage Co. RWD #7, KS	15.84	Purchased from City of Osage
1996	City of Reading	15.84	Purchased from City of Osage
1996	Osage Co. RWD # 6, KS	15.84	Purchased from City of Osage
1996	Omaha, IL	15.84	Self
1996	Village of Williamsburg, OH	14.56	Self
1996	City of Upper Sandusky, OH	14.38	Self
1996	Keysport, IL	14.42	Self
1994	Carthage, IL	15.84	Self
1994	Andersen Co., RWD #2, KS	15.84	Self
1994	Keysport, IL	18.7	Self
1994	Emma, MO	14.42	Self
1994	Louisville, IL	18.7	Self
1994	Vandali, IL	13.29	Self
1994	Canton	12.71	Self
1994	Cuba, IL	12.71	Purchases from Canton
1994	Norris, IL		Purchases from Canton
1994	Dunfer, IL		Purchases from Canton
1993	Three Rivers, IN*	20.1	
1993	New Haven, IN	20.1	Purchased water from Three Rivers
1993	Sunymede, IN	20.1	Purchased water from Three Rivers

The CWS serving Three Rivers, IN was not included in the VMS databases available to HED.